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The Software Developers' Magazine

APRIL 1991 VOL 5 ISSUE 10

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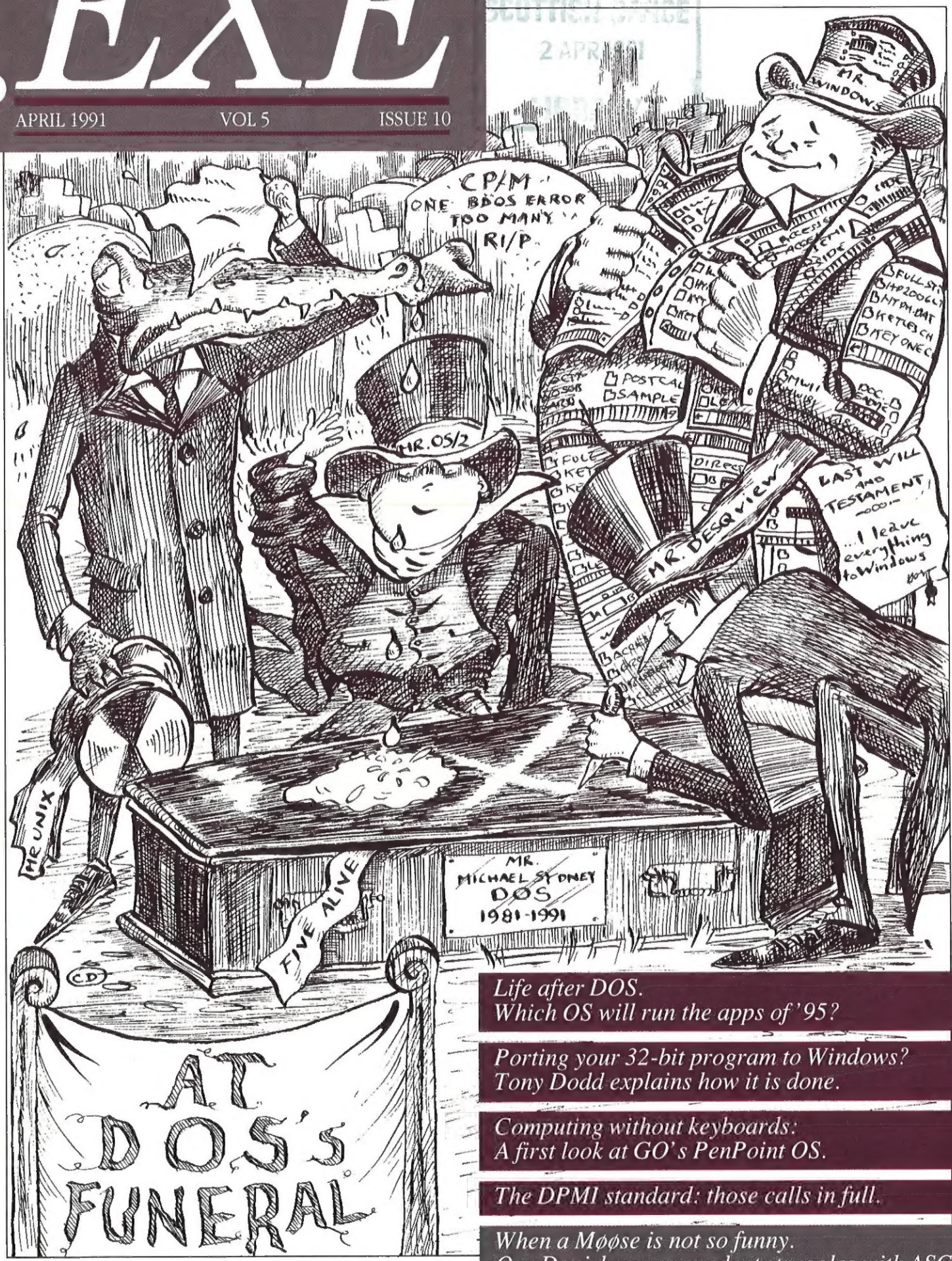

Life after DOS.
Which OS will run the apps of '95?

Porting your 32-bit program to Windows?
Tony Dodd explains how it is done.

Computing without keyboards:
A first look at GO's PenPoint OS.

The DPMI standard: those calls in full.

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Our Danish correspondent struggles with ASCII.

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Pronunciation
The name of .EXE Magazine is pronounced to rhyme with 'not sexy magazine'.

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Issue Theme - Life after DOS

32-BIT PROGRAMMING UNDER WINDOWS 3
How Tony Dodd got his 32-bit Prolog compiler running under the mostly 16-bit Windows 3 environment. 12

MIGHTIER THAN THE MOUSE
The writing is on the LCD display, according to Christopher Smithies, who has been looking at GO's new pen-based operating system. 18

TAKING THE XENIX PLUNGE
Richard Samworth has made the transition from DOS to XENIX. He has catalogued his early experiences for us. 26

FROM BROBDINGNAG TO LILLIPUT: GREETINGS!
DPMI is the latest mystery set of initials to emerge from the jargon factory. Dan O'Brien explains what they mean. 35

PERFORMANCE TUNING PARADOX
Andy Redfern has some tricks up his sleeve to get the best out of the PAL language. 46

A CANADIAN SOLUTION
Watcom's DOS and OS/2 C compiler has a 32-bit big brother. Will Watts has been taking a look. 56

SOAPBOX
John Barber dares to criticise the Programmer's best friend. 2

NEWS
We have two new debuggers for Windows, a Windows BASIC from an unexpected source, and even a few non-Windows stories. 4

LETTERS
The best way to test floating-point handling, and Zortech answers its critics. 10

THE THIRD SIDE
Dave Green says that Prolog is the mad computer language from Hell - but he's an enthusiast really. 62

FROM OUR OWN CORRESPONDENT
There are three shady characters at the end of the Danish alphabet who cause a lot of trouble. Ebbe Sønderby explains. 71

CODE PAGE
Do means mesmerize you and standard deviations make you shudder? Overcome your fear of stats as Robert Loughrey proves we're all Normal. 72

CROSSWORD
More clues from Eric Deeson, plus the answer to the March puzzle. 79

UNIX REGULAR
Peter Collinson takes a look at SoftPC: a package which reduces his Sun to a PC. 80

BOOKS
Undocumented DOS and very Documented UNIX are the subjects of this month's books. 88

STOB
Ms Stob has difficulties with a new piece of software. 96

Down with MAKE!

The MAKE tool takes some of the pain out of recompilation. But it should do rather more, argues John Barber.

What sort of a man am I, you ask, to be so unkind? Surely MAKE is every programmer's best friend? Maybe. But it seems to me that MAKE and other utilities which we use for software management do specific tasks well, but they don't reflect a realistic view of the program building process.

MAKE is sometimes criticised for allowing errors. When coding the make file for a large project with many include files, it's all too easy to omit a dependency. This, no doubt, prompted a recent comment that writing a make file for C++ was becoming more demanding than writing the source code. But this aspect is being addressed by the MAKE makers, who now provide Automatic Dependency Generators which do the hard slog of looking for include files.

My criticism of MAKE is at a more fundamental level. MAKE has been busy building programs for years, yet it still doesn't understand its own business. If you are sceptical about this statement, come with me and share my thoughts as I attempt to use MAKE for one of the simplest tasks imaginable: compiling a source file, without include files, to produce an object file.

* * *

'There. I've written a make file just as it said in the instructions. There are two lines. The first one says that my object file has one dependency:. my source file. The second line is a compile command which tells MAKE how to compile the source file if the object file is out-of-date. I'll try running it now ... yes, it's worked, and the object file has been created. I'll run it again to be sure ... it says my object file is already up-to-date, so it hasn't recompiled the source file. Splendid! That's just what I expected.'

'I've just remembered that I should have used a different compiler switch. I'll quickly edit the make file and run it again and...

What's this? It says the object file is up-to-date, it jolly (or words to that effect) - well isn't!'

'I will have to use TOUCH to change the time stamp of the source file. I know this will work, but it seems a bit like cheating, and I always forget. It's lucky that I was concentrating, or I might not have noticed that it hadn't compiled.'

'Perhaps I could be more clever. I'll include the name of the make file itself as a dependency. Then if I change the compiler switches again, I can be sure that the source file will be recompiled. When I add more modules to the make file I'll do the same again ... No, that's no good. If I change the make file, MAKE will think all the files are out-of-date, even the ones that aren't affected!'

'But wait ... I've really cracked it this time. I'm going to put every compile command in a batch file of its own, and call the batch files from the make file. Then I'll declare each batch file to be a dependency of...'

* * *

Using MAKE for such a common task shouldn't be so difficult, so what's going wrong? MAKE is crippled by its simplistic view that the only dependency is the input file. In real life, there will almost always be further dependencies such as the compiler options in the example above. To make matters worse, these dependencies occur in the commands of the make file itself.

It has to be admitted that programmers cope successfully with these difficulties every day, and most wouldn't dream of criticising MAKE; instead they are grateful for its existence. But the fact that MAKE is better than nothing shouldn't blind us to its limitations. Perhaps it is time to lay it to rest.

It's not difficult to see how a better MAKE might be implemented. What is needed is a mechanism for individually time stamping the contents of the make file - it shouldn't be too difficult.

I would like to suggest, though, that there is a wider issue. I used to think MAKE was wonderful. Why? Simply because that was what I had been told and what I had read. It took some time before my mind reluctantly accepted that MAKE was only a crude approximation of what was really needed. I have a horrible suspicion that the same is true of a great many other tools and methodologies which are regularly used by programmers.

EXE

John Barber is a freelance programmer specialising in graphics and user interfaces. Previously, he worked in the systems division of a large engineering company.

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CIRCLE NO. 646

dbVista V3.2

Raima has announced dbVista V3.2, dbQuery V2.2 and dbRevise V1.03. The new versions have a number of improvements: Raima claims dbVista 3.2 for Windows is twice at fast at writing, and ten times as fast at retrieval as previous versions. dbVista now supports Zortech's C++ V2.16. The company is also working on a set of class libraries for the same. Raima is distributed in the UK by SystemStar, who is on 0992 500919.

Nostalgia corner

DRA has recently obtained the rights to many of the old MicroPro products, which it is now marketing in this country. Included in the 'classic' products are WordStar 3.X (£79), WordStar 4 (£125), SuperSort (£125) and InfoStar (£199). DRA is on 0789 400681.

New Virus Hunter package

Defiant Systems have just announced V3 of their Virus Hunter package. The package has been enhanced in a number of ways, including extra specific virus detection, and the addition of an 'In Depth' mode, which claims the ability to deal with the sinister new stealth viruses, which conceal themselves by emulating low-level BIOS calls.

The package has also updated its resident auditing system, which has now been reduced from a 35 KB TSR to a 400 byte device driver. The package recently won Tandon User Group's Special Program of the Year award. Defiant is on 0752 265777.

DR DOS upgrade offer

A special offer from Digital Research : hand in your old copy of DOS plus £59 pounds, and get a nice new copy of DR DOS 5 back. Phone DR on 0635 35304 for details. The DR Upgrade Program will run until 31st of May.

Real time exec for 386

BSO/Tasking's Real Time Executive now supports the Intel 386 in real or protected mode. The system is fully pre-emptive, and libraries allowing direct interface with Microsoft and Turbo C are also available. BSO/Tasking is on 0252 510014.

Profiler for C

Solution Systems has announced the availability of Charge, a profiler for Microsoft C 5.1 onwards, QuickBasic, Turbo C and C++, Turbo Pascal, MASM and TASM. The system directly interfaces to Brief, allowing programmers to switch between the profile display and the source code. It retails for £79. Solution Systems is on 0763 244141.

Windows Developers

The Windows Development Association is a new meeting group for the UK Windows development community, which will be organising conferences and special interest meetings. An extensive 'Windows bookshop', WDA newsletter and a bulletin board service are also being offered. Membership costs £95.00 per annum for an individual membership, £380 for corporate.

The first conferences were on the 12th of March; one was on programming for Windows, and another on support. Topics addressed included memory management, compatibility with future releases, and DDE. More are coming up. The conferences are a half-day long, and cost £113 for members, £160 for non-members. The WDA are on 0285 640181.

Multiuser DOS from DR

Digital Research has announced a new multi-user, multi-tasking DOS which can support up to 64 users, each using up to eight tasks. Either terminals or PCs can be attached to the 80386/486 system running the operating system. The product is an amalgam of knowledge gleaned from DR's previous DOS products. The task-switching was taken from Concurrent DOS, and the product boasts the same levels of MS-DOS compatibility as DR DOS 5. Windows 3.0 will operate as a task. The filing system has been extended to include user and group file management, and there are also a number of security features, including login passwords, secure disks and hardware keys. The recommended retail price for Multiuser DOS is £495. Call DR on 0635 35304 for further information.

Integrated LISP

LISTPACK+ is a new implementation of LISP for MS-DOS, produced by Mirabilis software. It comes complete with a fully integrated development environment that includes a full screen structure editor, with LISP interpreter and compiler built in. The IDE looks a little primitive compared to other languages, but is certainly better than most PC LISP systems, with screen editing, error linking, automatic indentation and bracket matching, saving, printing and context-sensitive help. It looks and feels a little like early Borland products. The 'compiled' code runs under a LISP virtual machine interpreter: Mirabilis claims 3000 function calls or over 8000 CONS per second on a 12MHz 80286. While the package does not support low-level calls, there is a window interface included, with calls to support viewports onto virtual text screens, menus and forms. LISTPACK+ includes a distributable .EXE virtual machine and manual, and costs £79.50. For more information, phone Mirabilis on 0256 29839.

PostScript for Clipper

Scripton is a linkable library that allows Clipper programmers to lay out documents, select fonts and produce a number of graphics and special effects on a PostScript printer. The library works by returning a string of PostScript commands, allowing the programmer control over whether they should be output immediately, or stored in a file. For example:

```
set print on
? setpage()
? moveto(300,400)
? cshow("Hello")
? printpage()
set print off
```

Text oriented functions in Scripton allow the pen to be moved in conventional printer mode. Other functions draw lines, boxes, arcs and circles. The string returning structure also allows PostScript buffs to tweak the output. Scripton costs £155, and is available from QBS on (081) 994 4842.

Microsoft Launch New Windows Tools

Microsoft has unveiled two new tools for the Microsoft C Professional Development System V6.0. One is a new version of CodeView for Windows which allows single monitor debugging. The other is an extended memory compiler, which supports (but doesn't include) both DOS protected mode interface (DPMI) and VCPI DOS extenders.

The single monitor debugger works via a device driver, allowing programmers to switch between a text mode CodeView screen and the Windows desktop. The minimum system requirements for single monitor debugging are an 8MHz 80286-based PC or better, running DOS and equipped with at least 550K of extended memory, VGA and 5 MB of hard disk space.

The updates are free of charge to all users who purchase the Microsoft C maintenance update, V6.00a. Older registrees should contact Microsoft. The single monitor version of CodeView for Windows is also available from Compuserve in Microsoft's ACCESS area, as well as on our latest .EXE disk (together with the OLE documentation and other Windows developers' tools, such as Michael Geary's FIXDS utility).

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EXE 4/91

CIRCLE NO. 647

WIN A TRIP TO CALIFORNIA!

with BORLAND and .EXE magazine

Borland, the leader in object-oriented programming for DOS and Windows, is to host its first International Languages Conference in San Francisco's historic Sheraton Palace Hotel from April 28 to May 1, 1991 – and you could be there!

The conference has got to be the most important language event of the year.

Designed for software developers and technical managers, the conference will feature presentations from industry leaders on timely topics such as object-oriented programming, developing applications for windowing environments and increasing programmer productivity.

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How do I get there?

Simply answer the 4 questions below correctly and return the coupon. If you are one of the first TWO names out of the hat, you'll receive an all expenses paid trip to the Conference. Plus a free copy of **Turbo Pascal for Windows** AND **Borland C++.**

And there's more...

As second prizes, we're giving away FIVE free places (worth £295 each) on the London leg of the **Borland OOP World Tour**, Tuesday, May 21st, at the QE2 Centre, London. This is a major international seminar where the world's OOP experts will be sharing their expertise, and paying particular attention to OOP programming for Windows.

Second prize winners will also receive free copies of either **Borland C++** (the only complete C and C++ programming environment for DOS and Windows applications) or **Borland's Turbo Pascal for Windows.** Borland C++ comes with a complete set of tools including a Windows debugger, resource editor and compiler, and WINDOWS.H. – no SDK required! Turbo Pascal for Windows, the world's standard Pascal compiler, is the fastest way to develop Windows applications in Windows.

10 runners up will receive a copy of Turbo Pascal for Windows OR Borland C++ and a further 15 runners-up will receive a .EXE T-shirt of their choice and .EXE mug.

All entrants will receive a free Borland Language Information Pack.

Competition Questions

Q1: Who is Borland's CEO, President and Chairman?
☐ Bill Gates ☐ John Sculley ☐ Philippe Kahn

Q2: What was Borland's very first product (launched in 1983)?
☐ Lotus 1-2-3 ☐ dBase ☐ Turbo Pascal

Q3: Who, or what, is Rikke Helms?
☐ Madonna's real name ☐ An add-on library for Turbo Pascal 6.0 ☐ Borland UK's Managing Director

Q4: What programming magazine's name rhymes with "not sexy"?
☐ TV Times ☐ Viz Comic ☐ .EXE

Winners will be drawn from correct entries received by MONDAY, APRIL 15, 1991. Flight winners will be notified by fax/post the same day. All other prize winners will be notified by post. The judges' decision is final and no correspondence will be entered into. Cut the coupon and send your answers NOW to: Borland/.EXE California competition, Borland International, FREEPOST RG1571, Twyford, Berkshire RG10 8BR: **NO STAMP IS REQUIRED.**

PLEASE USE BLOCK CAPITALS

Name _____

Job Title _____

Organisation _____

Address _____

Telephone _____ Fax _____

If I'm a runner-up, I'd like to receive:
☐ Turbo Pascal for Windows ☐ Borland C++ (Tick one only)

Primary language used _____ Operating System _____

BORLAND SOFTWARE KNOW HOW

CIRCLE NO. 648

Multiscope Windows Emerging

A genuine Windows debugger - that is, one which actually works within a windows and not on a second monitor or text screen - is proving elusive. It isn't here yet. Those baiting their breath for the full Multiscope for DOS/Windows package (originally pre-announced in January) should continue to turn purple. Multiscope has, however, been demonstrating gamma copies of the run-time portion, and it does look impressive. The debugger is fully WIMPed, with separate, iconisable windows for all the main features. The data display and breakpointing design seems particularly impressive. The graphic data window shows structures in text-book format, with boxes, lines and arrows representing records, pointers and values. Breakpoint conditions can be expressed in the host language, and may include statements and even function calls. This allows new code to be attached to points in the program - quick fixes without recompilation. Multiscope has also adopted Superbase 4-like VCR controls, to simplify the control interface.

The launch has been delayed until June while Multiscope sort out the other two thirds of the package: a post-crash module, and a remote debugger (via serial port and network). MultiScope in the USA is, however, arranging an Advantage program, whereby buyers receive immediate shipment of the run-time debugger and documentation, with the rest following as they become available. QA Training markets MultiScope in this country - phone them on 0285 655888 for the latest information.

HP and Sun propose

Sun Microsystems and Hewlett-Packard have submitted a specification for a distributed Object Management Facility (OMF) to the Object Management Group, that would allow sophisticated information sharing over a network or between computers from different vendors.

OMF is based on the NewWave protocols, and is a best described as a high-level system interface - high enough to cope with differences between Sun's ONC and HP's NCS networking systems, but low enough to allow other object managers, such as OLE, to utilise it. The co-operative venture is all the more important as Sun is a big fan of Unix International, while HP is a founding member of the Open Software Foundation. Distributed OMF would also link DOS and Unix systems, and will allow developers to use any of several object-oriented programming languages as well as traditional languages.

Meanwhile, the Object Management Group has announced 12 new members, bringing the membership of the 'Open Systems for Objects' pressure group to 108 companies. The companies are: Cigna, Cinecom, CSX LIS, ERISOFT AB, Genesis Development Corporation, Hal Computer Systems, Hyperdisk, Informix, Qualix, Rational Consulting, Software AG and Stratus. Note that OMG has closed down its British offices, and moved back to Framingham, Mass, so the contact number given last month is now incorrect. Queries, and requests for copies of the Object Management Architecture Guide should now be directed through Eric Leach Marketing, on 081 570 2182. For further information on OMF, call HP on 0344 361428.

CommonView Expands

Glockenspiel has converted the Windows version of its CommonView class library (previously only available for their own C++ cfront preprocessor) for use with the Zortech and Borland C++ compilers. Glockenspiel's President, John Carolan, said that this was in line with his company's strategy of 'making CommonView available for any C++ compiler of suitable technical quality'. CommonView is also making the move to UNIX systems, with development work continuing with Glockenspiel's C++ with Motif and Open Desktop.

The Zortech and Borland libraries cost £399 and are available from QA Training (Tel: 0285 655888). Commonview can be contacted on 010 353 1733166

Digitally Mastered

The full text of .EXE has been available in CD form for some time, as part of the Computer Library service. Ziff, the publisher, has now released a new publication, Computer Select, aimed at purchasers of new products and services. The new package includes 67,000 complete product and vendor information from *Data Sources*, as well as over 60,000 articles and abstracts from 140 leading publications; including us, of course. The publication also contains *The Computer Glossary* by Alan Freedman, and Harry Newton's *Telecom Dictionary*, providing 8,000 in-depth computer industry terms. Computer Select costs $995 for a one-year subscription. Updates are distributed monthly. You'll need a PC, CD-ROM, DOS 3.1 and a High Sierra driver. Ziff's distributor in this country is International Software (081 479 0047).

Watcom p-code compiler
Watcom (0101 519 886 3700) has announced beta testing of its C/p16 compacting and optimising compiler, which uses p-code interpretation on areas of code that are not time critical. An unlimited, royalty free license for C/p16 costs will cost $5,000. The compiler is expected to begin beta testing in March, with general availability planned for June.

Intel loses trademark case
Intel (0793 696000) has lost the first battle in the war to enforce its copyright on 80386 chip manufacturers. Judge William Ingram has announced that the 386 is a generic product designation, and therefore cannot be trademarked. As a result, Intel will now be referring to its chips as the '1386(™)' and 'Intel386(™)' microprocessors. The more controversial issue - whether AMD has the right to copy what Intel claims are products incorporating Intel microcode, is still in the courts.

Marconi piracy case resolved
Marconi Instruments, the company which was served with an Anton-Piller order by the Business Software Alliance some months back, has reached an out-of-court settlement with the organisation. It has also agreed that it will be working with both BSA and FAST (the Federation Against Software Theft) to develop a model control and auditing system for general use.

Help compiler included
One of the criticisms made in last month's Borland C++ article has been addressed: Borland has arranged to license the help compiler from the Microsoft SDK, and this will now be included with the shipped package of Borland C++. Pricing details remain the same: £299.95 retail, £69.95 for Turbo C++ Professional users, £129.95 for Turbo C++ users. Borland is on 0734 320022.

Old Mac transfers
In last month's issue, we mentioned a product which could read Mac disks from a PC, Access Mac, but only if you had a new Mac with the 1.44 MB SuperDrives. Now Peripheral Land Inc has announced a $449 external SuperFloppy for older Macs. The SuperFloppy 1.4 features 94 millisecond average access time, an 8 KB buffer, auto-eject, external SCSI dial, external SCSI termination switch, and an external power supply. Peripheral Land is on 0101 415 657 2211.

Sycero C for Unix
Maidstone-based System C has announced a version of Sycero C, its database program generator, for SCO Unix System V, Release 3.2. The new package is directly compatible with Sycero C DOS source - code should port straight across - and requires no runtime licence. Sycero C Unix sells for £1865 including the code generator and file handler. Existing Sycero C users can purchase Sycero C UNIX for £970 if they own the networking version, or £1270 if they use the single user version. For further information, contact Judy Holly at System C on 0622 691616.

International Standards
Unicode is the new multilingual text and character encoding standard, organised by the larger multinationals. Unicode's backers, who include Apple, Go, IBM, Metaphor, Microsoft, Next, Novell and Sun, want Unicode to be the 16-bit equivalent of ASCII. The draft standard currently incorporates 27,000 separate characters. The group claims that Unicode is arranged to make international character handling as simple and efficient as possible. Now it has a corporation, Unicode Inc, to maintain and promote the standard. It can be contacted on 0101 408 988 8933.

WordPerfect toolkit
WordPerfect (0932 850500) has announced the availability of a toolkit documenting information on screen drivers, file formats, and DOS interrupts on all of the company's DOS based products - including Wordperfect Office's clipboard and hotkeying interface. The package costs £50.

Comsol catalogue out
Computer Solutions' new catalogue is now out. Products covered include the vsDesigner CASE tool; SAGE programmer tools; the Avocet range of compilers and cross assemblers, and a host of FORTH based embedded-system products. The catalogue is available from Computer Solutions on 09323 52744.

dGE upgrade
dGE V4.1, the upgrade to the popular PC database graphics library, is now available from Bits per Second. The new version includes The Graphics Language, which uses Clipper V5.0's User Defined Commands to simplify the calling of dGE functions. dGE will be including TGL support for other xBase compilers that offer UDL like capabilities. dGe V1.4 costs £245; Bits per Second are on 0273 727119.

Interactive gets UNIX V.4

AT&T and Intel have announced that Interactive Systems will be a 'principal publisher' of UNIX V Release 4 on Intel hardware platforms. AT&T has passed on the source, and Intel is transferring its entire UNIX software customer base to Interactive. The hope is that the company, whose V 3.2 is already well established, can bring the new version into wider circulation. The Interactive UNIX will also be iABI-compliant, allowing developers to produce shrink wrapped versions of V 4 applications. Interactive are planning what they call 'aggressive' migration plans to assist all existing and new System V 3.2 users in moving to the new version.

Picking up Pen

Twenty one hardware companies have announced support for Microsoft's Pen extensions to Windows 3. The announcement was made in late February, at the Pen Windows developers' conference held in Seattle. The manufacturers include CalComp, Canon, GRiD, Fujitsu, Hitachi, Kyocera, Sanyo, Sharp and Wang. A limited number of beta copies of the Pen Windows SDK are available from Microsoft at Excel House, 84 Caversham Road, Reading RG1 8LP, or by faxing 0734 596768. Send details about your company and the pen application you intend to develop.

Official C51 User Group

Hitex, one of the distributors of Keil compilers in this country, has broadened the base of its C[80]51 user group. The group was originally formed as a free technical exchange for Hitex's UK registered users, but the company has now been given permission from Keil to turn the group into an international, official user group. Telephone/FAX technical support with guaranteed response times.

Details are available from Hitex's Sarah Batting on 0203 692066. Membership is free for registered Keil users: unregistered users can receive the newsletter for £10, but should phone for an application form first.

BASIC for Windows

Blackwell Scientific Publications, better known for its hardbacks than its software, has announced WinBasic, a BASIC interpreter that runs in and supports Windows. The system is being sold primarily as an introduction to Windows programming, and also as a prototyping system for C programmers.

An interesting point to the product is the manner in which it implements Windows' event-driven nature. This sample program correctly handles mouse, menu and key press messages from windows. All the event dispatching is performed invisibly by the interpreter, rather than by using the traditional ON MOUSE type construction. Some labels are preset, like _KEY and _MOUSE events, while others (like the menu options in the example code) are set up by the user. If a label doesn't exist, WinBasic executes the appropriate default action. BASIC programs can also read and write dBASE files, so you can run those quick file-conversion hacks as a background Windows process. WinBasic sells for £99.50. Blackwell Scientific is on 0865 240201.

```
Dim Menu$(4)

Menu$(1)="Menu1 MenuItem_1001 MenuItem_1002"
Menu$(2)="Menu2"
Menu$(3)="Menu3 MenuItem_3001 MenuItem_3002"
Menu$(4)=""

Menu Menu$

_1001:
_1002:
  a$=Chr$(GetMessage%()-1000+48)
  MessageBox a$+". Item", "Menu1", 0, answer%

_2000:
  MessageBox "Direct working", "Menu2", 0, answer%

_3001:
_3002:
  a$=Chr$(GetMessage%()-3000+48)
  MessageBox a$+". Item", "Menu3", 0, answer%

_KEY:
  a$=Inkey$()
  Print a$, Asc%(a$)

_MOUSE:
  Mouse Button%, x%, y%
  MoveTo x%, y%
  Print "Button "; Button%
```

NDOWS NOW SUPPORTS WINDOWS 3.0 AND MICROSOFT C6.0 NOW SUPPORTS WINDOWS 3.0 AND MICROSOFT C6.0 NOW SUPP

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Transaction processing	✓	
Automatic recovery	✓	
Record and file locking	✓	
RAM resident		✓
Relational Query and report writer	✓	
Total database redesign/restructuring	✓	
C compilers: most supported	✓	
C ++ compatible	✓	
Operating Systems: VMS, Ultrix,	✓	
UNIX, BSD, SunOs, XENIX, QNX	✓	
MSDOS, MS Windows and Macintosh	✓	
OS/2 compatible	✓	
LANs: Netbios and Appleshare	✓	
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Training courses available	✓	
Run-time Royalties (Absolutely NOT)		✓
*using WKS Library		

The db_VISTA III™ database development system is intended for use by the professional C applications developer. db_VISTA III is written in C and provides a complete set of sophisticated development tools that feature:

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CIRCLE NO.

Letters

We welcome short letters on any subject that is relevant to software development. Please write to The Editor, .EXE Magazine, 10 Barley Mow Passage, Chiswick, London W4 4PH. Unless your letter is marked 'Not for Publication', it will be considered for inclusion on this page.

Testing floating point

Sir,

Your March article, 'Software from Hardware' requires comment about programming and computing. You say you borrowed some professional C programming which does Gaussian elimination on a specified matrix. When run in the 32-bit compiler answers could be as much as 4% different from those common to two bit compilers. This is a ridiculous difference. It may indict the 32-bit compiler or, possibly, your Cyrix 387-compatible coprocessor; you will have noticed, in the same issue of .EXE, the comment by Peter Anderton of NAG, 'the results given by some floating-point processors can be dangerously inaccurate.'

Gaussian elimination involves a clearly defined number of arithmetical operations for any specified matrix. Differently compiled programs should be very similar in their machine operations and, therefore, in their accumulated truncation errors. Operations other than the raw arithmetic should contribute little to these errors. If the input matrices you used were large, most of the run time would have been used doing arithmetic so timing differently compiled programs would then give a fair estimate of the compiler efficiency with respect to the simple arithmetic of addition, multiplication and such.

The ridiculous 4% difference in the answers forces one to consider computing rather than programming. Firstly, Gaussian elimination is not the recommended way to invert a matrix. Its variant, Gauss-Jordan, is preferred for reduction of both error and data storage. This method is set out simply in Contribution I/3 of *Linear Algebra* by Wilkinson and Reinsch, where the theory and program are followed by a practical discussion of error. This excellent reference book is used by the computer, the human computer that is, but rarely by the programmer. The test run it gives inverts a section of the Hilbert matrix because we know the exact answer to its inversion. If one uses some random input matrix to invert one has no idea what the correct answer should be using float-point arithmetic. The Hilbert matrix, its inverses and much more are given in *A Collection of Matrices for Testing Computational Algorithms* by Gregory and Karney. If you are to test other 32-bit C compilers on matrix inversion you could save your self a good deal of effort by using the Hilbert matrix as your guinea pig. You could make the arithmetic as lengthy as you wished by increasing the size of the input matrix and you would not even need to input the matrix manually as it is so charmingly simple that a couple of lines of programming would input it for you.

A tougher approach to the error problem would be to do perfect arithmetic using rational numbers in place of decimal ones, but the work...

It is hardly fair to ask you to tackle rational arithmetic but if you want to compare other C compilers for both speed and reliable arithmetic then using traditional test data like the Hilbert matrix is desirable. It would be interesting, also, to see the results with parallel compilations not using the 387 coprocessor.

H Herne
Expert Consultants
Kent

The upside of Zortech

Before I get too depressed by John Cant's review of our C++ Database library *('Zortech and the Database', March '91)*, I would like to do ever such a tiny Baghdad Radio job on his article:

'A great deal of effort has gone into designing a highly valuable toolbox of classes which will be of great value in themselves, and as building blocks for larger structures.

'Zortech has taken a courageous and laudable stand in providing source code for its class libraries.

'Apart from some simple bugs which were quickly fixed by Zortech, I did not find it necessary to delve into the depths of the ISAM file system. The functionality provided was just fine.

'The design of C++ classes is inherently much more complex than that of ordinary library functions.'

On that last point, there is at present a limited population of programmers who are prepared to take the job on. Equally, there is a shortage of programmers willing or able to join in the process of β-testing such products. Obviously, with hindsight, we would have welcomed John on the β-test program.

Also with hindsight we have to admit that the weight of testing during development of the library went into the Btree index and file management classes, including their multi-user capabilities.

The combination of these two factors may account for some of the problems John had with the 'User Interface' of the Database++ library. It is worth remembering that most programmers' function libraries have no user interface whatsoever. Also, the multi-user example presented was intended to be skeletal rather than fully fledged. It is just not possible to pre-judge what use will be made of relatively low-level components of this sort.

At the time the product was issued, all bugs reported by b-testers had been fixed.

Prior to the publication of John's article, all the bugs he mentioned to Zortech had been fixed, and a fixed version sent to him.

As far as I know, at the time of writing all reported database bugs have been fixed, and there is a liberal upgrade policy.

John's remarks about the ISAM file system are particularly welcome. The classes implementing this are the major element of the product, and although it was not particularly visible I get the impression that we got points for those.

Steve Teale
c/o Zortech Ltd
North Yorkshire

Letters submitted to this page may be edited. The writer of the best letter of the month, as judged by the Editor, will be rewarded by a T-shirt or similar-valued .EXE trinket. The best letter is the one printed first.

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If you are building sophisticated C++ applications for MS Windows or OS/2 PM, you could benefit from

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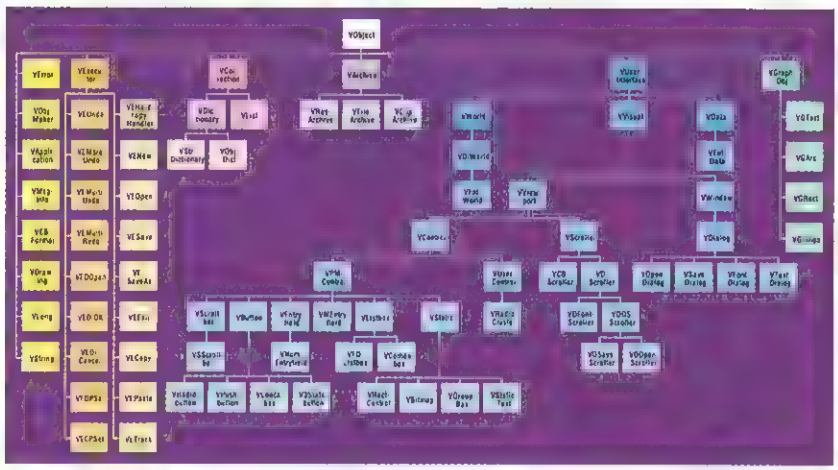
You don't really want to invest your valuable time in reinventing the GUI-wheel?



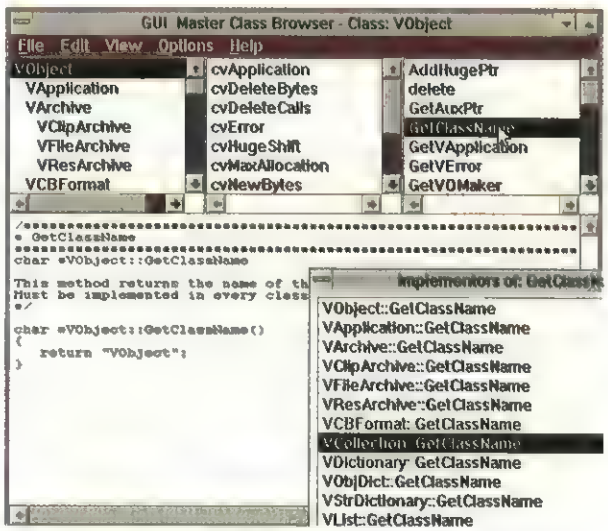
- We don't, so we included over 85 classes containing a wide range of GUI building blocks. Anything that could be accomplished through "normal" programming can be done if you use our product. It's just a lot easier
- Many of the things you might not include in your application because they're too complex or time-consuming to program, are easy to make with *GUI_Master (CLASS-TREE for C++)*
- We provide the Interface Builder, with which you specify all properties of the visual objects of your program. The interface builder then generates the necessary source code, the resource specifications and even the make file
- The Browser enables you to examine your own code and code made by others, and to understand the class structure of that code. From the Browser you can launch the editor of your choice to modify a C++ program

You may want detailed reference documentation

- We supply nearly 1200 pages of detailed class descriptions, method reference etc. An index is included, of course

You may need a cookbook and example programs

- We provide 7 functional example programs and a cookbook explaining the "how to's"



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- A C++2.x compiler, as we do not supply a compiler with our product. We suggest using the Zortech compiler, but we have also tested most of the others. Write for details

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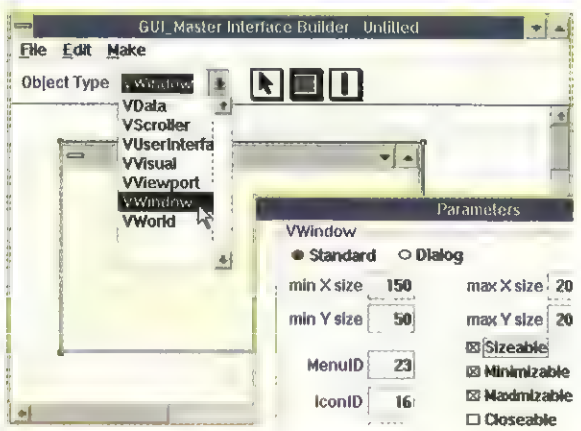

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CIRCLE NO. 650

32-bit programming under Windows 3

When Tony Dodd found that Windows 3 did not offer the 32-bit API he needed to port his Prolog compiler, was he dismayed? Well, yes; but he managed to get round it.

When I discovered the notes tucked away at the back of the SDK Reference for Windows 3 advertising support for 32-bit applications my first thought was 'why hasn't this been accorded more importance?' and my second was 'why is it so small?'. The answer to both questions is the same: Windows 3.0 only supplies functions that you could not write yourself because of the processor's protection mechanism. It doesn't provide functions that you would expect to find in a normal development environment.

However, systems programmers can take these functions and use them to make 32-bit applications accessible to users. This article describes how I ported one such application, Prolog-2, which is an implementation of the Prolog language for PCs. I hope to encourage other developers to change their languages and toolkits so as to provide easy access to the full power of the 80386 for those who cannot cope if only given the bare essentials supplied by Microsoft.

Because this is an article for system developers, and because a small book would be needed to explain all the conventions, standards, architectures and interfaces involved, I shall assume that the reader already understands the different members of the 80386 family.

Protected mode programs

The 80386 processor contains a museum of old PC architectures too complex for consideration here. To summarise very briefly:

- if the processor operates in real mode then it behaves very like an 8086;
- if the processor operates with the virtual 8086 bit set then it behaves rather like an 8086 but uses paging so that the 8086 memory need not be the first 640 KB of physical memory;
- if the code being executed is in a small code segment (a `USE16` segment, as the assembler calls it) then it behaves like 80286 protected mode code.

We have all got used to PCs running in real mode when the operating system is MS-DOS, and protected mode when it is OS/2; but Windows 3 has changed all that. There are three modes:

- in real mode the processor is in real mode;
- in standard mode the processor is in protected mode but switches to real mode to run DOS applications;
- in 386 enhanced mode the processor is in protected mode and DOS applications are run as virtual 8086 tasks.

We shall only be concerned with Windows applications in this article, so we must address the problem of writing protected mode programs. In fact this isn't usually a problem. Compiled C programs should not make assumptions about the values in segment registers, so the program should not care whether segment registers contain physical addresses (as in real mode) or offsets in a table (as in protected mode). A few problems may be envisaged: for example, what about huge arrays? How can the compiler produce portable code to pass a 64 KB boundary? The solution in Windows 3 is particularly ingenious: successive segments that tile an area greater than 64 KB are arranged in sequence in the segment table, so that the distance between them is fixed. In real mode this distance is also fixed - it is 1000H. So in each case a constant needs to be added to a segment register to pass a 64 KB boundary; and this constant is defined appropriately by the Windows kernel.

System services

Suppose we agree, then, that it is not impossible that a Windows application will run in protected mode as well as in real mode. Directly or indirectly the code will almost certainly issue DOS calls through interrupt 21H; should we assume that these will work too?

The answer to this question must be a resounding no. First, DOS operates in real mode, and makes assumptions about segments that prevent it from running in protected mode. Second, any parameters passed to DOS that use segment registers will be interpreted quite wrongly; DOS will convert them to linear addresses by multiplying them by 16, which isn't the idea at all. Third, protected mode interrupts do not use the interrupt locations in low memory; they use a separate interrupt table.

Issuing interrupts in protected mode and hoping that they will work as in real mode is therefore not advisable. However, in order to make Windows applications operate correctly in protected mode, Microsoft provides almost all DOS services via the protected mode interrupt 21H (which, as we shall see later, is a 286 trap gate). The few restrictions are summarised in Figure 1.

It should be noted that providing these services involves more than the translation of a few addresses. For example, to read from a file into a buffer at a protected mode address is straightforward only if the pro-

tected mode address has a real mode equivalent; otherwise some clever remapping of pages is called for. For this reason, more obscure DOS calls cannot cope with transfer of more than 4 KB of data at a time.

A few DPMI calls are of use to the Windows programmer, however. *(For a detailed description of DPMI, please see Dan O'Brien's article elsewhere in this issue - Ed.)* For example, access to an interrupt other than 21H may require direct use of DPMI. My example shows how the DOS case conversion function may be accessed from protected mode; of course, Windows 3 already has a perfectly good case conversion function, but the use of the DOS version serves as a nice simple example.

Recall that DOS call 38H returns, among other things, the address of a procedure that can be called to convert a character to upper case. As this address is only suitable for use in real mode, we must use a special DPMI call to invoke the routine from protected mode. A parameter block containing the desired register settings in real mode is built and passed to DPMI; the code for the example is given in Figure 2.

Of course, code like this must be used with caution; it will not work in real mode. Programs that need to do such low-level operations must use `GetWinFlags` to find out which mode the processor is in.

32-bit programs

32-bit code offers the programmer tremendous advantages. The full address space of the machine can be accessed from a single offset register, without the use of segments. Segments are still useful as a relocation and protection mechanism, but they are no longer needed as a way of accessing large blocks of memory. My own PC software product, Prolog-2, has always been hampered by the segmented architecture; languages like Prolog like to have a large pool of memory available in which objects of any size can be allocated and deallocated at will. Huge arrays are no solution, and most PC Prolog implementations have had to restrict run-time stacks to 64 KB. The 32-bit architecture of the 80386 solves all that.

Unfortunately it is not that simple. Presented with a chip that at last lifted the major limitation of the 8086 family of processors and made available 32-bit facilities comparable to those that had been in every other major processor for years, what did Microsoft and IBM do? They designed a new OS that prevented code from running in 32-bit mode. They forced users to operate their nice new 80386 processors as fas-

Function	Description	Status
00H	Terminate Process	Not available
0FH	Open File with FCB	Not available
10H	Close File with FCB	Not available
14H	Sequential Read	Not available
15H	Sequential Write	Not available
16H	Create File with FCB	Not available
21H	Random Read	Not available
22H	Random Write	Not available
23H	Get File Size	Not available
24H	Set Relative Record	Not available
25H	Set Interrupt Vector	Only affects protected mode vectors
27H	Random Block Read	Not available
28H	Random Block Write	Not available
35H	Get Interrupt Vector	Only affects protected mode vectors
38H	Get Country Data	See text for details of how to call the case mapping function
44H	IOCTL	In functions 2,3,4,5 do not specify more than 4K of data. Function C not supported.
65H	Get Extended Country Information	See 38H

Figure 1 - Limitations of DOS calls in protected mode

```
; This code calls a real mode routine. The
; address to be called is in EBX (real
; segment in top half) and the argument is in
; AX. If [EBX] is the address of the DOS case
; mapping call and AX has a character code
; then AX will return with the converted
; value.
        sub     ESP,34H         ; allocate the call

                                ; block (34H bytes)
        mov     EDI,ESP
        push    SS              ; Call block address
        pop     ES              ; in ES:DI
        push    AX              ; save argument
        push    EDI
        mov     ECX,34H
        mov     AL,0
        rep     stosb           ; zero block
        pop     EDI
        pop     AX
        mov     1CH[EDI],AX     ; set real mode AX..
        mov     EAX,[EBX]       ; .. IP and CS
        mov     2AH[EDI],EAX    ; note: real mode
                                ; stack will be

                                ; supplied as SS=0
        mov     AX,0301H        ; DPMI call real mode
        mov     BH,0            ; reserved flags
        mov     ECX,0           ; leave the stack
                                ; alone
        int     31H             ; DPMI
        mov     AX,1CH[EDI]     ; get answer
        add     ESP,34H         ; clear block
```

Figure 2 - Using DPMI to access a real mode function

```
alloc     dd      ?
selector  dw      ?
...
          push    alloc             ; amount to allocate
          push    DS                ; FAR pointer to selector
          push    OFFSET selector
          push    alloc             ; max size of allocated object
          push    WORD PTR 0        ; reserved
          call    Global32Alloc
```

Figure 3 - Allocating a 32-bit segment

```
          mov     ECX,20000H        ; number of bytes
          mov     EDX,0             ; buffer address
          mov     DS,selector
          mov     AH,3FH
          int     21H
```

Figure 4 - Reading into a 32-bit segment - wrong!

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ter versions of the ghastly old 80286, and every few months they made an announcement about a 32-bit version of OS/2 being available at some unspecified future time.

A short term solution was the DOS extender. A DOS extender is a small 32-bit operating system that can be bound with a 32-bit application and run from DOS. The DOS extender switches the processor into protected mode, and offers services comparable to DOS services to the application; it may also allow it to communicate with real mode code. I used the Phar Lap DOS extender for the 80386 version of Prolog-2; it is an excellent system, well tested across a range of odd PCs and very nicely documented. Virtual memory support is also available. But there are problems with DOS extenders:

- a DOS extender application cannot run as a DOS application under Windows 3, though this will be fixed when DOS extenders support DPMI.
- a DOS extender application cannot run as a Windows 3 application, and I know of no plans to fix this.
- DOS extender vendors charge run-time licence fees. Though this would not be too unreasonable if one were selling a packaged application, there is a problem for those selling language compilers that require the run-time support of a DOS extender; people who use the language to ship applications must pay run-time fees to the DOS extender vendor.

The services that a DOS extender offers may be divided into groups:

- it switches the processor between real and protected mode.
- it loads applications.
- it offers operating system services to applications.

We have seen that Windows 3 offers all these services as well; but only for 16-bit applications. On the other hand, whereas moving from real to protected mode requires a processor mode switch, a `USE32` segment is a mere long jump away from a `USE16` segment.

There is one technical difficulty: Windows normally allocates `USE16` segments for code. To load a 32-bit application it is necessary to get a large data segment, read the code into it as though it were data, and then change the segment to a `USE32` code segment. Because Windows 3 applications cannot use privileged instructions, it is impossible to go and hack these segments out of the segment table: but Windows 3 provides a set of functions, grouped in the 32-bit DLL (described in Appendix E of the SDK Reference Manual), that perform just the tasks required.

In summary, then, to run a 32-bit application under Windows 3 we need a loader program that will load the code as described and transfer control to it, and we need to supply the code with system services.

Of course, we also need a 32-bit application. Several compilers and assemblers are available; I use the Phar Lap set. Whichever you use, make sure that you have a description of the linker output format, as you will have to load the code yourself. Make sure that the application is written to use a single segment for all code and data.

Loading a 32-bit application

Loading a .EXE file is not one of life's great pleasures. But apart from the odd page size, most of the annoyance derives from the need to fix up segments. In a flat 32-bit application that problem does not arise: there should be no segments hard-coded into the program. For various odd purposes, like accessing the PSP, my Phar Lap program used fixed integer segment numbers; such things must, of course, be removed, because they assume the particular segment usage of Phar Lap's own DOS extender.

Before loading the program you need to know how much memory to allocate, how much memory to load, where the stack pointer is to go and where the code begins. All these items will be available in the header, though the exact format will differ from linker to linker. In more detail, the sequence of operations is:

- open the file to be loaded.
- read the header and extract the fields you need.
- use `Global32Alloc` to allocate the desired amount of memory.
- read the load image from the file into memory.
- close the file.
- use `Global32CodeAlias` to get a code segment alias for the data segment.
- switch to the application stack.
- perform a long jump to the start address.

Because the loader program needs to mix 16-bit and 32-bit offsets in a complicated way it is easiest to write it in assembler. The loader segment needs to be declared as `USE16`. Remember to use Pascal calling conventions for Windows routines; in other words, push the first argument onto the stack first. Thus the initial call to allocate memory may be as in Figure 3 which leaves the return code in AL and the segment selector in `selector`.

Reading the load image requires some thought. If there are 20000H bytes it will not do to use the code in Figure 4, because DOS will ignore the top half of the ECX register and simply read 0 bytes. The file must be read in portions smaller than 64 KB. So we may start with the code;

```
mov     ECX,0C000H
mov     EDX,0
mov     DS,selector
mov     AH,3FH
int     21H
```

reading the first 0C000H bytes into memory. This works ok, but it should be clear that adding 0C000H to EDX and doing the same again will not work. It will correctly read the 4000H bytes of code starting at DS:0C000H, but at the end of the 64 KB segment DOS will wrap around and start again at DS:0.

Fortunately there is a call available to remedy this: we can obtain a new selector for a segment starting at DS:0C000H, as in Figure 5. Such a selector is called an *alias*, and allows you to tile segment selectors so that the whole of a very large segment is covered by tiles whose individual sizes are less than 64 KB. Now the data may be read using the code;

```
mov     ECX,0C000H
lds     DX,alias16
mov     AX,3FH
int     21H
```

When the operation is finished, the 16-bit alias should then be freed with `Global16PointerFree`.

```
alias16     dd      ?
            ...
            push    selector                ; Segment to be aliased
            push    DWORD PTR 0C000H        ; Offset to be aliased
            push    DS                      ; FAR pointer to alias16
            push    OFFSET alias16
            push    DWORD PTR 0C000H        ; Size of alias segment
            push    WORD PTR 0              ; Reserved
            call    Global16PointerAlloc
```

Figure 5 - Getting a 16-bit alias

```
aliasc      dw    ?
            ...
            push  selector            ; segment to alias
            push  DS                  ; FAR pointer to aliasc
            push  OFFSET aliasc
            push  WORD PTR 0          ; reserved
            call  Global32CodeAlias
```

Figure 6 - Getting a code segment alias

Jumping into the data segment that we have just loaded with code would cause an error: but getting a code segment alias is straightforward: see Figure 6. At this point all that remains is to start the application, as in Figure 7. It is for the sake of tricks like this that we must program in assembler.

Generally assemblers have not caught up with mixed `USE16` and `USE32` segments. The assembler can only cope with `near` and `far` procs. In a `USE16` segment a `near proc` pushes just a return offset on the stack while a `far proc` pushes a 16-bit offset and a segment on the stack; but nothing pushes a 32-bit offset and a segment. Similarly with return statements.

In the instruction encoding of the 80386 processor there are not separate opcodes for 16 and 32 bit operations. Instead, the processor looks for a 32-bit operand in a `USE32` segment and a 16-bit operand in a `USE16` segment; but the code generated is just the same. How, then, can a 32-bit operand be used in a `USE16` segment? The answer is the size override byte, which has no symbolic name but happens to be 66H. We have to define `big`;

```
big   macro
      db        66H
big   endm
```

and insert the override in the code stream ourselves. (Of course, you can just put

```
db    66H
```

in the middle of your program if you insist).

System services

You cannot use int 21H instructions in the 32-bit part of your program and you cannot link it with library routines that contain such instructions. Interrupt 21H in protected mode is a 286 trap gate, which means that when it returns it will pop a 16-bit offset off the stack, and therefore, probably, return somewhere strange, say in the middle of an instruction.

System services must be provided within the 16-bit part of the application. It is, therefore, necessary to allow the 32-bit code to call the 16-bit code (probably you need to call the Windows library too, and every so often yield control to other applications).

It isn't possible to link the `USE32` segment directly with the loader program, for obvious reasons. Instead the `USE32` routine should be replaced by a stub that calls across to the 16-bit using a jump table. Thus, suppose that we have a routine `openf(char*)` that opens a named file. Instead of opening the file directly the `USE32` routine may say something like the code;

```
_openf  proc
        call    [jtable+OPENF*4]
        ret
_openf  endp
```

All that this does is to look in a jump table to find the address of the 16-bit open routine and transfer control there: `OPENF` is a suitable literal. The jump table must be initialised at the start of the `USE32` code based on a table passed by the 16-bit code.

A pointer to the name of the file to be opened is passed on the stack. Provided that the `USE32` program keeps its stack below offset 10000H, the two programs can use the same stack, and I would strongly recommend doing this if possible. If use of a high level language forces you to put the stack higher than this then every call to `USE16` code will have to switch to the 16-bit stack and copy the appropriate number of arguments from the `USE32` stack; and afterwards, switch back.

Another problem will arise if the name of the file is above offset 10000H; this is hard to avoid. In that case you can either copy the name lower (but this gets very tedious in some cases, such as buffered I/O) or you can take a 16-bit alias of the address as we did in reading the load image. Provided you write a general purpose table based interface rather than generating each piece of code separately, this is the better approach.

```
        lss     ESP,appstack
        push    aliasc
        push    appstart      ; 32-bit start address
        big
        ret
```

Figure 7 - A 32-bit call in a USE16 segment

Conclusion

It is hard to estimate the work involved in converting any application. It is a great advantage that you need only convert calls used by your application; you don't have to produce a general purpose interface. I will only say that it took me much less time to convert Prolog-2 than I had expected.

I suppose it would be fair to say that 32-bit programming under Windows 3 is not for the timid. Later releases will make it easier. For the programmer who needs to deliver 32-bit applications on the PC, the Windows 32-bit DLL has unique advantages: it's available now, it works, and you can give it away with your application.

PS

Microsoft has announced that there will be a 32-bit version of the Windows API, called *Win 32*. This will make all the contortions described in this article unnecessary, and it will be possible to link 32-bit code directly with the Windows libraries. Moreover, the next release of Microsoft C will come in two forms: 16-bit or 32-bit. The developer's tools for Win 32 are due to be shipped in late 1991, but there will not be a retail version based on DOS until 1992; moreover, it is expected that many users will stay with 16-bit Windows.

More immediately, the WLO libraries allow Windows applications to run under OS/2. OS/2 1.x will not support WINMEM32.DLL, but OS/2 2.x together with WLO 1.0, which will be part of the SDK for Windows 3.1, will allow WINMEM32 calls. So anyone developing a 32-bit application in the way described in this article should be able to supply a common .EXE file that will work both with Windows and with OS/2. *(We will be printing an in-depth article on WLO in the near future - Ed.)*

Tony Dodd is the Chairman and Managing Director of Expert Systems Ltd. He was the designer of the Prolog-2 implementation of Prolog-2 and has written textbooks on Prolog and on Prolog implementation. He can be contacted on 0865 794474, or via Email at tdo@uk.ac.exeter.cs.

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CIRCLE NO. 653

MIGHTIER THAN THE MOUSE

After three years of unparalleled secrecy, GO Corporation has announced an object-oriented OS for a new kind of machine: the pen-based PC. Christopher Smithies has been evaluating the system.

On 22 January 1991, after a period of undercover productivity, GO Corporation unveiled its new operating system: PenPoint. At the launch, GO demonstrated PenPoint on a pen-based machine of its own design and manufacture, and representatives from hardware producers IBM, NCR and GRiD gave brief presentations attesting their commitment to the new system. What, then, does GO offer to attract such interest from third parties?

The User Interface

With the mouse/keyboard interface, it is frequently necessary to issue commands in two steps: first, get to the right place with the mouse, then key the appropriate command.

With a pen, one simply writes the command in the appropriate place. Under PenPoint, commands may be alphanumeric characters (which make use of handwriting recognition) or meaningful gestures: caret for insert, cross-out for delete, square brackets for block-marking, question-mark for help, and so on. A corollary of this is that there is no cursor. Characters and commands are entered wherever the pen is put down. The pen becomes, as it were, a 'random access' device and potentially represents as big a step forward for the user interface as the move from tape to hard disk did for data processing.

The user interface is based on the familiar desktop concept. But whereas the older GUIs do everything with windows, PenPoint also offers a different metaphor: the notebook.

A notebook presents itself as a window almost filling the screen. It is subdivided into pages, each of which roughly corresponds to a disk file. The initial page is a table of contents, presented in much the same way as the table of contents in a printed book - see Figure 2.

A page may be selected by a pen-tap on its name, and may be turned-to by a tap on the page number. As a convenience, the user may add any number of index-tabs to a notebook. This is achieved by writing the letter 'T' over any entry in the table of contents. This causes a tab to appear on the right-hand margin of the notebook window. A single pen-tap on any tab will cause the appropriate page to be turned-to (ie the appropriate document or file to be displayed as a notebook page).

As you can see from Figure 2, the table-of-contents display is self-explanatory. The underlying software is replete with features which are invoked with easily memorised gestures. For example: to create a new document one might make a caret ^ mark (for 'insert') at a particular place on the table of contents. A menu appears offering a range of possible document types, known as 'stationery'. One makes a selection by tapping with the pen upon the appropriate menu item (eg 'Notepaper'). A new page with the name 'Notepaper' appears on the table of contents, inserted in the chosen place. If we were to turn to it, this new page would be blank.

Of course, 'Notepaper' is a generic title. One would probably want to rename the new document, thus giving it a specific identity. This is done using the same modify command as would be used to change a word in a document, or a line in a drawing. You just use the modify gesture: draw a small circle over the word 'Notepaper'. When the modify gesture has been issued, an edit box appears. See Figure 3.

In turning to a page of the notebook, a dormant application is brought to life. Under PenPoint, the operator does nothing specifically to load or activate an application: this is regarded as part of the outmoded disk-based concept. An application is permanently loaded upon installation and a new process is initiated whenever a document is created. This process would normally 'sleep' when the document is not displayed.

All representations of datasets are referred to as 'documents'. Applications are considered not from the point of view of the running process, but rather from the input forms necessary to provide them with data or the output views representing these data. Input forms and output views of data are accessed as pages within the notebook.

- commands issued via pen gestures and handwritten characters
- window-type GUI using notebook metaphor
- handwriting recognition integrated into system
- pre-emptive multi-tasking
- object-oriented design
- instant power-up/power-down support
- can use any host filesystem (currently MS-DOS)
- multiple simultaneous network support, automatic logon/logoff
- deferred input/output
- device-independence
- user-interface components (window layouts, fonts etc.) scalable
- transparent file and directory system
- flexible and powerful inter-process communication

Figure 1 - Salient features of PenPoint

Objects of Desire

glockenspiel CommonView 2

***Glockenspiel CommonView** has really made its mark in the world of Windows development. Thousands of developers have used it to speed up and simplify their projects.*

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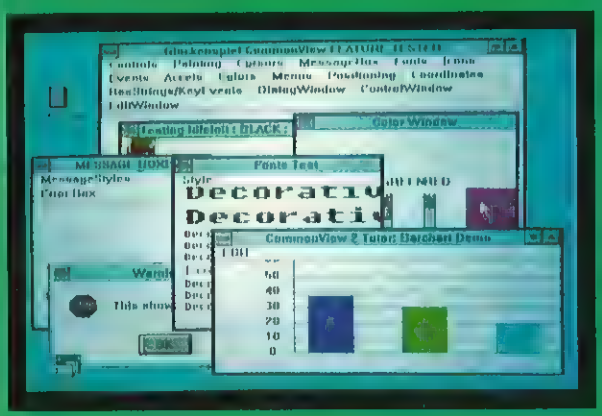
That's because **CommonView 2** works with **Glockenspiel C++ 2.0**, giving you a C++ object-based framework that reduces the complexity, cuts the code, manages memory and lets you stay in touch with what you're really doing. From compilation to execution, **CommonView 2** applications are fast and powerful.



CommonView 2 objects model the real world of Windows. And that's just the beginning - from there **CommonView 2** takes you as far as you want to go.

It doesn't anticipate everything. That's where C++ takes over: its inheritance capabilities enable you to extend the **CommonView 2** framework. Just take an existing object and customize it without affecting the original. A few additional lines of code and you could, for example, turn an edit control into a password control. Then reuse it in other applications.

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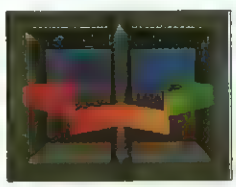
Specifications.

Glockenspiel CommonView 2 includes Glockenspiel C++ 2.0 and Container - the object storage framework. It requires Microsoft C 6.0, the Windows SDK and 1.5 meg of memory. You debug C++ source with Microsoft CodeView 3.0. Glockenspiel C++ supports a completely portable memory management system. Glockenspiel CommonView consists of approximately 65 classes.

Comprehensive documentation includes CommonView tutorial and reference manual, Glockenspiel C++ compiler manual and User Guide, C++ syntax and AT&T Library Guide, pullout guide to compiler switches, *plus* "Programming in C++" by Stephen C. Dewhurst and Kathy T. Stark (Prentice Hall).

On-line hypertext documentation for CommonView reference manual and AT&T guides. Tutorial source code also on disk.



Glockenspiel C++ works from within the Programmer's Workbench with the reference guides instantly available from the on-line Advisor, using Microsoft CodeView for debugging.

Glockenspiel CommonView applications are portable between Windows 2.1 and Windows 3.0, PM 1.1 and PM 1.2 with HP New Wave 3.0 version coming soon.

glockenspiel
class constructors

QA

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Glockenspiel Professional C++ 2.0 Compilers are available for DOS, OS/2 and Workstation platforms. Call for details.

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CIRCLE NO. 655

A database application might be implemented via several notebook pages; some of these pages might present input forms for the addition of data to the database, while others would present reports (or browsers) on the current contents of the database. Rather than explicitly request a particular report, therefore, the user would turn to the appropriate page in the notebook. The concept of 'groups of pages' is supported via the concept of notebook 'sections', within which sub-documents may be individually selected. This notion directly corresponds to the traditional hierarchical directory model. Any number of notebooks can co-exist on the desktop. The help system, for example, uses a separate notebook. Notebooks may be viewed on the desktop or iconised. The area of the desktop where iconised notebooks appear is known as the 'bookshelf'. Both notebooks and individual pages may also be 'floated' in a window above the desktop.

Input/output jobs are queued by system services. A printout can be initiated even when the printer is not connected. Any number of (named) printers can be simultaneously available. Suitable elements in the printout queue are printed automatically when the appropriate printer device is connected. The system supports auto-detection of connection to peripherals and networks, so that output is processed automatically when the connection is made. Similar facilities apply to disk backup and input of, for example, faxes and electronic mail.

One of the most powerful features of the system is called 'embedding'. This effectively allows views or part-views of one notebook page to be included within another. The mechanism is particularly powerful in that once a given document is displayed through the embedding mechanism, the application responsible for that document is activated whenever it is on display and controls the way the display is managed. Thus it would be possible to embed a dynamically-updated graphical entity (eg a pie-chart updated by network events) within a text document; what would be embedded would not be a particular bit-map (ie a 'frozen' record of the pie-chart data at the time the display was embedded) but rather a dynamic entity which kept itself updated whenever it was on display. Embedding is wholly transparent to the applications programmer.

Handwriting Recognition

Handwriting can be stored either in compressed bit-map form or it can be translated into machine-readable form (the system uses a variety of RTF). At present cursive recognition (reading joined-up handwriting) is yet to be achieved, but hand-print is reliably recognised. GO Corporation has implemented its own recognition engine, which may be trained to individual styles; third-party recognition engines may be substituted. GO has researched this area very thoroughly and claims 95% accuracy. Speed is not a problem, particularly since recognition proceeds concurrently with the I/O handling of pen events.

The handwriting recognition engine (HWX) is typically invoked in one of four modes: dictionary-checked, numeric-only, template-controlled or free.

Our experience suggests that the GO HWX is powerful and fast enough to win wide acceptance. GO itself is however encouraging third parties to compete in this field, in the interests of the quality of the final product. At least one US company is already working on an alternative.

System Architecture

A novel feature of PenPoint is its object-oriented design. About 5% of the code is in assembler; the remainder is written in C, the bulk of which is fully object-oriented code. I will discuss the implementation of the

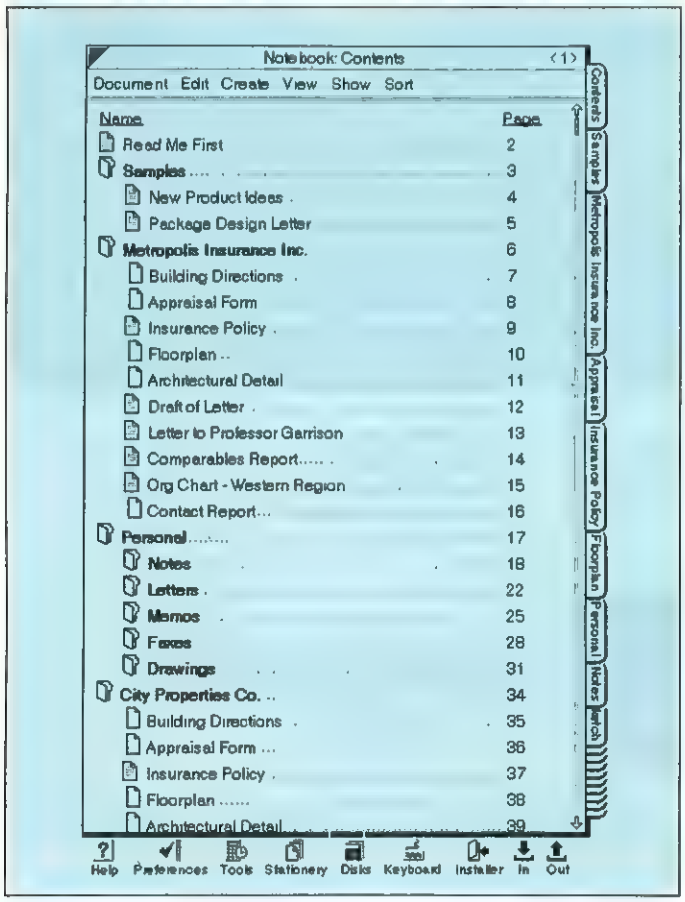

Figure 2 - The PenPoint Notebook

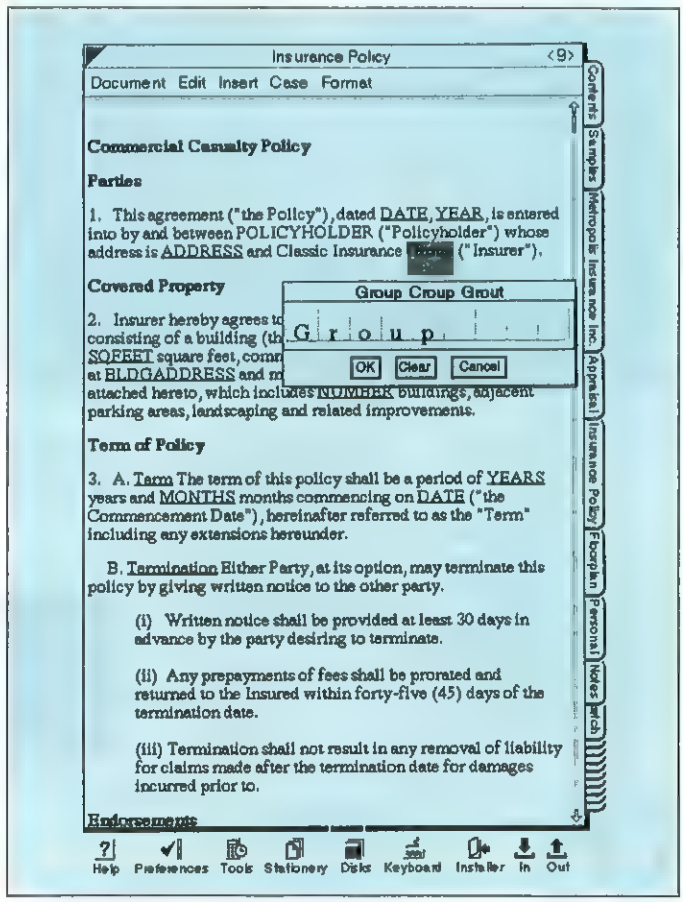

Figure 3 - The PenPoint Edit Pad

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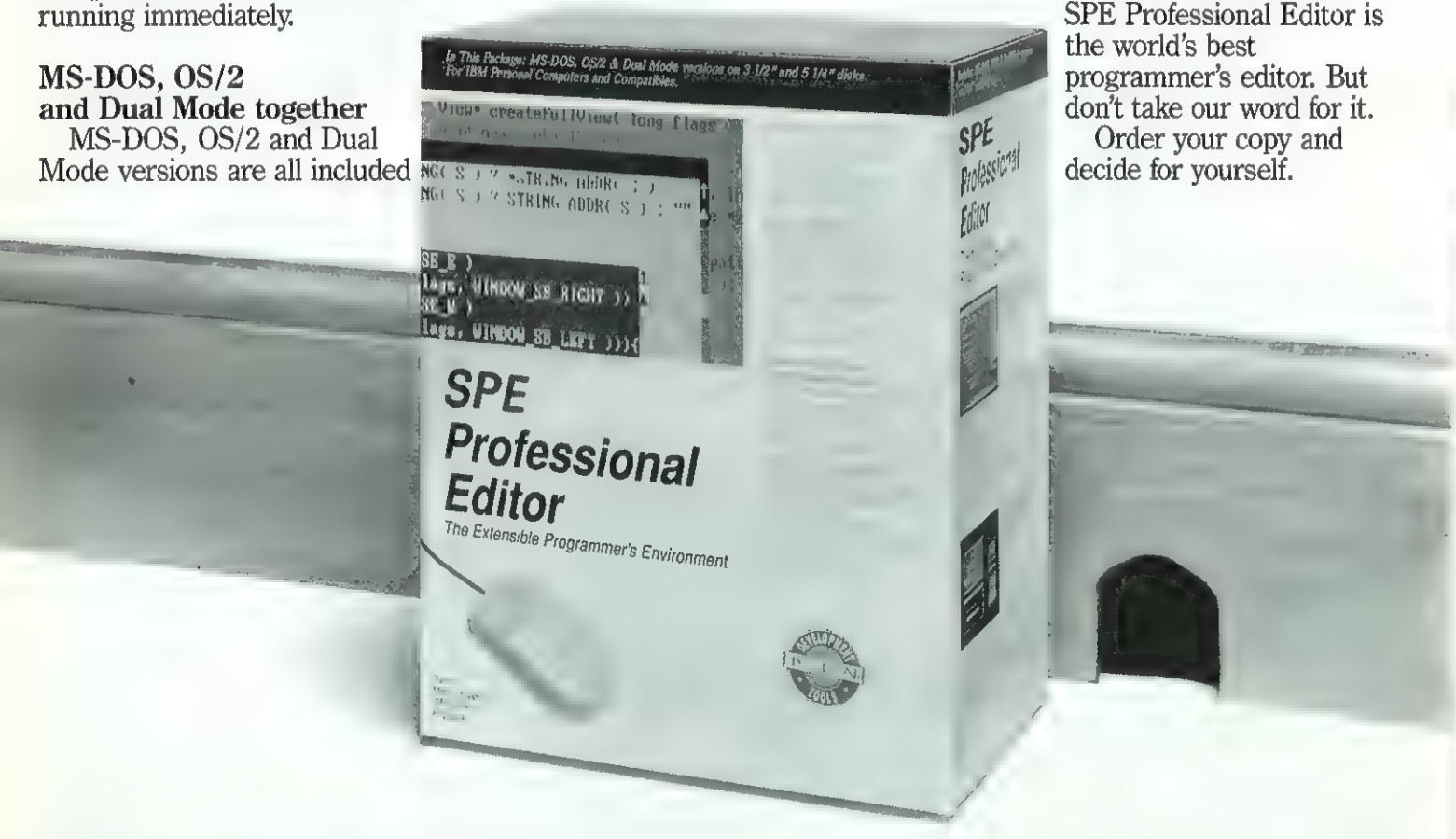

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CIRCLE NO. 657

```
Remote Interfaces and File System
  ATP              Provides AppleTalk support
  DirHandle        (eg theWorkingDir, theSelectedVolume)
   AppDir          directory devoted to one application instance
  FileSystem       (eg theFileSystem - used to locate installed volumes)
  Modem            eg fax, data
  ParallelPort     Provides parallel port support
  SoftTalk         Provides TOPS SoftTalk API
  Stream
   FileHandle      Provides file handling support
    ObjectFile     Provides object files for instance data.
    ResFile        Resource files store objects and data by Resource ID.
   Service         general-purpose DLL for network protocols, device drivers,
                   filesystem volume types...
    INBXService    Input mailbox
    OutBoxService  Supports deferred output
     Prn           Implements the abstract functionality of a printer driver.
      BndPrn       Implements a line-oriented printer driver
       Epson       printer driver for a dot-matrix printer
       Pcl         printer driver for the PCL language
       Pscript     PostScript printer driver; can also generate EPSF
                   PostScript files
   Sio             serial port support
   Xfer            inter-task communications
  Transport        remote process communications
  TopsMounter      access to TOPS servers
  Volume
   VolRAM          RAM disk, implements data compression
   VolMSDisk       Implements PenPoint file system on MS-DOS disks
   VolTOPS         Implements PenPoint files on remote volumes via TOPS
  VolSearch        filesystem UI support, eg formatting, duplicating
```

Figure 4 - The PenPoint Object Hierarchy (part)

object system in greater detail, .EXE Editor willing, in a subsequent article.

The object hierarchy is elaborate and of course extensible by the applications programmer. Its object classes fall into the following principal areas:- Remote Interfaces and File System, Text and Handwriting, Applications, Installation and Windows and UI toolkit.

To give the complete class hierarchy is beyond the scope of this article, but details of those classes relating to remote interfaces and file systems are shown in Figure 4.

In principle, much of the work of a GUI application will be done by code permanently present in PenPoint. Because of this level of OS support, a GUI application for PenPoint should be considerably smaller than an equivalent application under Microsoft Windows or OS/2 Presentation Manager.

The file/process system is unusual in that every dataset has an associated process. This is supported primarily by a RAM filesystem, and secondarily by a disk filesystem.

The RAM-resident filesystem employs hardware memory access protection where available. Currently this must be SRAM or non-volatile memory of some kind; GO plans to support DRAM (which is faster and cheaper, but can consume more power) in the near future. The organisation of the RAM volume is roughly mappable on to an MS-DOS or UNIX filesystem, but unlike disk-based filesystems it intrinsically supports data compression. PenPoint document names may include embedded spaces and punctuation, and there are many PenPoint-specific file and directory attributes.

For disk handling, the designers of PenPoint superimposed their filesystem onto that of MS-DOS. The auto-detection facility in the system provides 'hooks' whereby any disk compatible with the drive hardware could be used. Because PenPoint can emulate hierarchical directories, extended attributes and 32-character filenames by means of system disk files, PenPoint can theoretically be hosted by any filesystem. Currently, MS-DOS, RAM and 'remote' (ie networked) volumes are handled; Macintosh HFS is likely to be added.

Graphics I/O devices are supported via a device-independent coördinate system, which apparently owes much to the PostScript language for its base concepts. PostScript-type files are used to specify graphics objects generally. This design offers very 'WYSIWYG' performance. Faxes, for example, are stored internally at their fullest resolution; a fax can be marked-up using the pen at the fullest resolution of the pen digitiser (irrespective of the screen resolution) and retransmitted without any degradation of the image.

Much has been done to make interesting and flexible GUI programming comparatively easy. In particular, the system supports 'smart' window component layout so that, for example, a form can be displayed in either portrait or landscape format without the programmer needing to work out absolute screen locations. The system will arrange multiple elements tidily and sensibly so as to achieve a well-spaced layout under all conditions; for example it will auto-scale or word-wrap boxed text. This minimises reliance on a given graphics video device and improves the portability of GUI applications across different screen and print devices.

The entire system is event-driven. An application's 'main' routine receives control only upon installation and when an application dataset ('document') is created. Subrou-

```
/* method.tbl - contains the method table for clsEmptyApp. */
#include <clsmgr.h>

/* To describe the methods used by the application, we use a
 * method table: a zero-terminated array of struct MSG_INFO.
 *
 * a MSG_INFO contains the message number (a MESSAGE),
 * the handler function name
 * and flags to control the message-passing protocol. */

MSG_INFO clsEmptyAppMethods[] = {
  msgDestroy, "EmptyAppDestroy", objCallAncestorAfter,
  0
};


/* we use a class table to describe the classes used by the application.
 * This is a zero-terminated array of struct CLASS_INFO.

 * a CLASS_INFO contains the name to use for the compiled table,
 * a pointer to the method table (above)
 * and flags (reserved, zero) */

CLASS_INFO classInfo[] = {
  "clsEmptyAppTable", clsEmptyAppMethods, 0,
  0
};
```

Figure 5 - Method Table for Skeleton Application

tines are not called by 'main', but by the operating system upon receipt of some kind of event. All code must be re-entrant and is written to react to specific input events. Typically, an application will define certain responses to certain input events: the 'main' routine will install certain entities in the system and then 'sleep' for ever.

Applications in use on the system are permanently loaded. Because of this, it is not useful to speak of 'loading': rather, one speaks of 'installation'. There is a permanent process for each application which supervises in a global way the interaction of that application with the system. For example, this permanent process can handle installation, de-installation or re-installation, import of datasets from foreign systems, etc. Applications can be informed of specific 'home' directories, which exist on individuated external media (eg a floppy disk with a unique volume ID) onto which they can save/restore their state to free up memory.

The Developer's angle

The PenPoint operating system is remarkable for its user interface and its strong design. Applications written for this system should be smaller and more portable than under any other because of the high degree of user-interface support and device-independence the system offers.

The implementation of an object-oriented OS in C is open to criticism. At the time when GO commenced the project, no suitable implementation of an object-oriented language (and arguably only C++ would have the requisite low-level potential) was available for the target hardware. The object system is closely modelled on Smalltalk ideas. All binding is done at run-time.

The source code for each application consists of two components: a method table, which defines the classes used by the application and the methods responded-to thereby, and the source of the application itself. Figures 5 and 6 show these two source components for a skeletal application. This application creates just one class, namely, the application class. Processes are thought of as multiple instances of an application, so an application is implemented as a class - a subclass of `clsApp`. The class responds to just one message, `msgDestroy`, which is handled by the vacuous function `EmptyAppDestroy`. This is, in effect, the sole method of class `clsEmptyApp`. Before compiling the application source in Figure 6, the method table in Figure 5 has to be pre-compiled by the GO method-table compiler. This produces METHOD.H, which is then included in the C source.

GUI programming is a complex and cumbersome business in C. Programming for PenPoint is certainly no exception, as will be apparent from Figure 6. GO has made extensive use of the preprocessor to simplify the operations of inheritance, specification of function parameters and 'magic numbers' within the system. Unfortunately macros can obscure as much as they clarify; and the C preprocessor is not really up to the task. Already other GUIs have been simplified by object-oriented 'wrappers' supplied by third parties and there is a big opportunity here with PenPoint. There are already some excellent packages appearing (eg PenApps from Slate corporation) which vastly simplify the generation of truly natural pen-based applications.

The Competition

The reason for the obsessive secrecy surrounding the development of PenPoint is now apparent. Days after the launch, Microsoft announced Pen-Windows. A Pen-Windows developers' conference was held recently, with all those attending bound by non-disclosure agreements. What little is known about Pen-Windows suggests that Microsoft is intending to bolt

```
/* emptyapp.c
 * This is a skeletal application: it has no window,
 * nor any state it needs to save.
 * This class does respond to one message
 * (EmptyAppDestroy), so it has a separate method
 * table and a method to handle that message.      */
#include <app.h>     // for application messages
                     // (and clsmgr.h)
#include <appmgr.h> // for AppMgr startup stuff
#include <string.h> // for strcpy().
#include <method.h> // method function prototypes
                     // generated by MT

/* EmptyAppDestroy - responds to msgDestroy */

STATUS LOADDS CDECL FAR
EmptyAppDestroy(
  const MESSAGE msg,
  const OBJECT self,
  const pArgsType pArgs,
  const CONTEXT ctx,
  const pInstData pData
) {
  // this is where any response to the message
  // would be coded...
  return stsOK;
}


/* ClsEmptyAppInit installs the EmptyApp application
 * class and links the new instance to its method
 * table.                                          */

STATUS FAR PASCAL ClsEmptyAppInit(void) {
  APP_MGR_NEW  new;     // struct used to announce
                        // new app manager to the OS

  // Install Empty App class as descendant of clsApp.
  if ((s = ObjectCall(msgNewDefaults,
                      clsAppMgr,  &new)) < stsOK)
    return s;

  new.object.uid = clsEmptyApp;
  new.object.key = (OBJ_KEY)clsEmptyAppTable;
  new.class.pMsg = clsEmptyAppTable;
  new.class.ancestor = clsApp;
  // no instance data: size is zero
  new.class.size = Nil(SIZEOF);
   // no msgNew args of its own
  new.class.newArgsSize = SizeOf(APP_NEW);
  new.appMgr.flags.accessory = true;
  strcpy(new.appMgr.company, "GO Corporation");
  strcpy(new.appMgr.defaultDocName,
                              "Empty App document");
  return ObjectCall(msgNew,  clsAppMgr,  &new);
}

/* main - application entry point (as a PROCESS -
 * the app's MsgProc is where messages show up once
 * an instance is running).
 * This routine gets called in two situations:-
 * at installation, and at instantiation (ie when
 * a new piece of 'stationery' handled by this app is
 * created by the user).  main() can detect which
 * situation by looking at the processCount
 * parameter.                                      */

void FAR CDECL main (int argc, char **argv,
                     U16 processCount)
{
  if (processCount == 0)
  {                     // installation
    ClsEmptyAppInit();   // Create application class
    // get app monitor to install this app
    AppMonitorMain(clsEmptyApp, objNull);
  }
  else
    // create an application instance
    // and dispatch messages
    AppMain();
}
```

Figure 6 - Skeleton Application Source

a pen interface onto its existing Windows product. GO's argument is that a bolted-on pen layer will never allow software developers sufficient system support to produce a truly natural pen-controlled user interface.

Another competitive issue is the consistency of the user interface. PenPoint presents a completely consistent notebook metaphor which requires no understanding of the underlying computer system. Windows has an inconsistent desktop metaphor (when have you seen a trash-can on a real desk? or a Program Manager?). People need to understand computing before they can use Windows; GO says this is not the case with PenPoint.

More significantly, Microsoft is believed to be rewriting Windows as an object-oriented system. When this has been done, Microsoft will certainly be in a better position to compete.

PenPoint is aimed at a new class of machine, portable enough to be usable in a warehouse or an aeroplane, discreet enough for a court-room or a board meeting. GO envisages PenPoint running on machines varying in size from shirt-pocket to drawing-board. The PenPoint desktop machine of the future could have a screen literally the size of a desktop.

Why did GO decide to produce such a radically new system, rather than aiming for compatibility with existing GUI systems? GO would answer: as well as being far easier to control than the keyboard/mouse GUI, the pen-on-screen interface is so radically different, and raises such different possibilities, that the only successful way to produce a good pen-based application is to design it from scratch. Therefore, GO saw the quest for keyboard/mouse applications compatibility as ill-conceived: even if it could be achieved, it would be to the detriment of the pen interface. Rather, the issue is one of data compatibility and device/network connectivity. This issue GO has addressed at a fundamental level of the PenPoint system.

When can I have one?

The PenPoint release demonstrated at the launch was a developers' beta issue. It will run on an 80386 PC-AT for debug purposes, but the ideal development environment consists in networking a GO computer to the AT via TOPS. GO's computer is the size (and about the weight) of a well-built photograph album. It has a 100 dpi LCD screen, but no keyboard! It contains an 80286, typically with around 8 MB of RAM, and runs in Protected Mode. GO has no plans to supply this machine to the mass market.

The commercial V1.0 release, superseding the segmented 80286 version, will run on an 80386 only and will use a flat memory model. The move to the 32-bit world is mainly for portability not speed: GO is keen to have PenPoint running on non-Intel kit. GO is looking to ship V1.0 late in the year.

IBM, NCR and GRiD are all committed to supplying a hardware platform for PenPoint: the race is on to be ready for the commercial release. NCR and GRiD are keeping their options open, and will also be offering Microsoft Pen-Windows when it becomes available.

EXE

CPK Smithies is technical director of Peripheral Vision Limited (Tel. 0373 52755). His language of choice is C++. He is a viola player.

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CIRCLE NO. 658

Taking the XENIX plunge

Richard Samworth was an MS-DOS programmer who needed to get into the big 'U'. Here, with a view to illuminating the path for those who follow, he describes his early battles with XENIX.

In 1980 Microsoft purchased a source code licence for the UNIX operating system from Bell Labs. In those days, it was fashionable to modify UNIX and then release your own version. This is exactly what Microsoft did. The company called it 'XENIX' and it ran on Intel 808X processors. XENIX is now marketed by the Santa Cruz Operation (SCO) as SCO XENIX System V.

Microsoft built some awareness of MS-DOS into XENIX. The operating system comes with a system file called `dos` that loads MS-DOS from the XENIX bootstrap prompt, and a selection of utilities which allow the exchange of files and directory information between the two operating systems. The XENIX Development System has tools for cross compiling applications developed under XENIX so they will load and run under MS-DOS. Later versions of XENIX will also support an OS/2 partition.

Moves towards UNIX standardisation have led SCO to develop the 'merged' product, SCO XENIX System V Release 2.3. Release 2.3 runs applications intended for AT&T UNIX System V/386 without recompiling. Further merging is planned. The 'merged' product lines are only available for 386 processors. Over the years, XENIX has collected a wide variety of PC and PS/2 specific libraries and drivers (described by SCO as 'value-added enhancements'). These are not available with AT&T UNIX System V/386 Release 3.2.

SCO calls XENIX 'the World's most popular UNIX system'. We demur to go this far, but it certainly is one of the most widely-used UNIX systems around.

Hardware

SCO XENIX V will run on Intel 80286 or 80386 processors. In practice, because of the memory management loads imposed by the operating system, 386 processors are preferable.

SCO recommends a minimum of 1 MB RAM for the core system and 500 KB for each additional user. It also suggests that extra memory may be required if the system will be running large applications such as databases or the Development System.

My first mistake with XENIX came with the disk drive specification. I had been told that a 70 MB hard disk was the minimum practical size for anyone wanting to run MS-DOS and XENIX on the same system. For no better reason than that it was large and inexpensive, I decided to buy a Seagate ST-296N 80 MB drive with an ST02 SCSI XT/AT controller board. The disk duly arrived and was installed. The instructions explained that there was a driver to map the device into MS-DOS, so we modified CONFIG.SYS, rebooted the system and hey-presto, acres of fast disk. Then we tried to install XENIX. It wouldn't. Several calls to the disk supplier followed. We changed the DIP switches on the mother board, then the disk controller, then practically everything else. Still no joy. Finally, we got desperate and read the manual. Appendix A, Compatible Hardware, section A.7.8 explains:

Many hard disks will work with XENIX system V Operating System. Whether or not a disk works depends upon the controller board. Here are two tests the controller must meet:

1. The disk controller is fully compatible with the standard controller for that configuration.

2. No special vendor software is needed to make the controller work under DOS.

We are currently using a Seagate 4096 80MB drive with a Western Digital WD1003V MM2 controller.

SCO XENIX V

SCO XENIX System V is a multi-tasking multi-user operating system for IBM compatible micro computers. It comes in a large box and your first task is to assemble the documentation. When you have finished, you should have the *Installation and System Administrator's Guide*, the *User's Guide*, the *Tutorial booklet* and several other shelf-straining binders. You will need to manufacture some space for the manuals (see Figure 1).

I found that you really do have to read the Installation Guide carefully, paying particular attention to Appendix A. This Guide and the Tutorial are the only manuals that don't assume that you know what you are doing. Culture shock intensifies when you reach the Maintenance section of the System Administrator's Guide. XENIX, unlike MS-DOS, needs constant petting and looking after; the System Administrator is the poor innocent charged with system maintenance and operation. In a single-user environment, system administration can be done by whoever happens to be using the system. In a multi-user environment, one individual should be nominated as administrator and made responsible for back-ups etc.

Loading XENIX

In my experience, you should allocate a whole day to the task of getting XENIX up

Name	Width	Weight
XENIX and Development System	1' 6"	1 st 4 oz
AT&T System V documentation	11"	1 st 5 oz
GCI and Text Processing system	6"	4.5 oz
K+R plus two general books	3"	3 oz

Figure 1 - XENIX documentation: the facts

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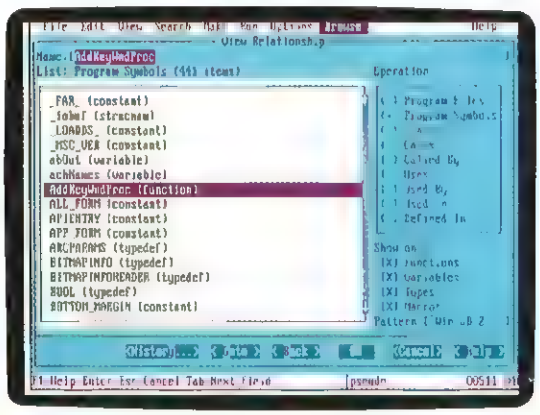

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and working. Your first act should be to cut all incoming phone lines.

Start by doing a low-level format on your hard disk and partitioning it. If you want to have MS-DOS on the hard disk, it must live in the primary partition. The documentation says, 'starting your DOS partition on cylinder 0 can cause the DOS partition to become inaccessible after installation.' In cylinder 0, MS-DOS writes its boot block next to the end of the XENIX masterboot block. Presumably, under certain circumstances, the XENIX masterboot block can change size.

Having partitioned the disk you can FORMAT, SYS and generally treat the MS-DOS partition as a normal hard disk without affecting other partition(s).

XENIX installation requires much typing in of horrible serial numbers and passwords. These are written on that series of small blue cards that fell under the desk when you opened the bag of disks. Now is a good time to pick them up again and stack them in a neat pile.

Now for the great moment. Put diskette N1 in the floppy drive and reboot. This will load the XENIX bootstrap program:

```
XENIX System V
Boot
:
```

The first decision you have to make is about keyboard type (Norwegian/Spanish/British etc). The boot procedure then loads `badtrk`. If the disk is already partitioned, this should report a DOS partition and one for XENIX. You should make sure that the XENIX partition is active.

If XENIX is being installed onto the hard disk for the first time, you can use the 'thorough scan' option to identify any bad tracks. Don't do this if you are in a hurry: a 150 MB disk will take over two-and-a-half hours to complete. You will need to allocate some space for extra entries in the bad track table, the default is 15.

Swap space allocation can be set to the system default or calculated manually, see Figure 2. Swap space size has a dramatic effect on system performance and can only be changed by re-installing the operating system. It is, therefore, important to get it right.

If you are installing XENIX on a hard disk (or partition) which is larger than 20 MB, you will be asked if you want to divide the XENIX partition into two separate file-systems: root and user. A separate, user file-system (usually known as /u) is not essential, but does offer various advantages. Access to all the files in a file-system is achieved through a structure called the Super Block. The Super Block is maintained in memory and written out to disk every 30 seconds by a process called `update`. There is a UNIX variant of Murphy's law which dictates that the operating system will always crash when the Super Block is most out of date. An unexpected power-off will also damage the file-systems.

During a system crash, a less active file-system will sustain less damage than a more active one. Keeping volatile files in the `/u` file-system reduces activity in the root. Should XENIX crash, it can be re-booted into the root and the /u file-system can be re-created by remaking it and restoring from back-ups made by the system administrator.

Having made the file-system(s), the installation process will ask for the operating system activation key and password.

When these have been entered, the system will reset and may be safely powered off. You can now boot from the hard disk.

The installation continues and copies the Operating System basic utilities from the utilities diskettes. You are prompted for a password for the superuser account 'root'. This password gives its owner maximum privileges.

For time-zone, set 'hours west of Greenwich' to '0' and ignore daylight saving time. The time can be adjusted when necessary from GMT to BST during boot-up. Don't use the abbreviation 'BST', as XENIX takes this to mean Bering Straits Time in Alaska.

If all has gone well, the minimum XENIX run-time system is now installed. If you continue the installation procedure, it will run `custom`, which allows you to install SCO supported products from their respective release diskettes.

Logging In

Each time you juice up the PC, it comes up with:

```
XENIX System V
Boot
:
```

If you have a bootable MS-DOS partition, you can type 'dos' at this stage, and the machine will load MS-DOS without the need to boot from a diskette. Entering 'xenix' (or just pressing the ENTER key at the prompt) starts the XENIX boot procedure.

As we have seen, *stopping* XENIX is more difficult than just switching off the machine. For a start, you must be logged in as 'root'.There are two commands that will legally stop XENIX, `haltsys` and `shutdown`. `haltsys` is abrupt and acts at once; it should be run if you are the only user. `shutdown` is more polite, and closes the system down after a (user specified) number of minutes. It also broadcasts warning 'log off now' messages to all users before killing all the active processes and tidying up. Doubtless many a wag has broadcast a facsimile shutdown message and laughed himself silly at the anguished roars from around the building as people try to save their work.

Systems using major applications (a large relational database, for example) should allocate swap space according to the following formula. The Development System is considered a major application.

1. Multiply the number of users on the machine by the size of the largest process normally run on the machine, in 1 KB. If no unusual processes apply, use 512 KB per user.
2. Take the amount of memory installed and add 256 KB. Compare this result with the result from step 1. Use the larger number as the swap space size.
3. Adjust the number upward if multiple users are running different large applications. Try adding 512 KB per different large application. (Consider the Development System to be a large application.)

For example, the calculations for an 8-user machine with 4MB of memory and a typical mix of spreadsheet, database, word processor and graphics package:

1. 8 users x 512 KB = 4096 KB
2. 4096 KB memory installed + 256 KB = 4352 KB, which is greater than the number calculated in step 1.
3. There are 4 users using different large applications. 4 x 512 KB = 2048 KB. Add this to the greater amount from steps 1 and 2 to obtain a reasonable calculation of swap space: 4352 KB + 2048 KB = 6400 KB. Since the operating system uses a block size of 1K, the swap space allocation translates to 6400 blocks.

Figure 2 - Swap Space Calculation

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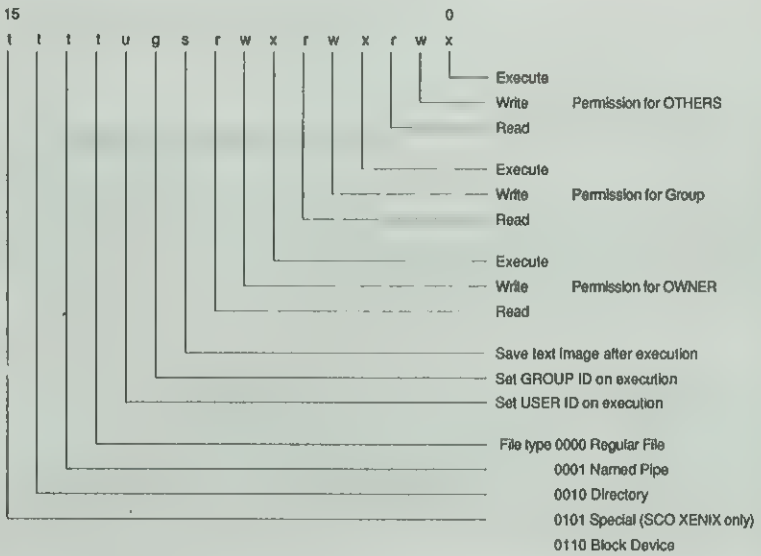
You can log in to XENIX as 'root' or as a user. The basic system only contains one account: the root. New user accounts are created by logging in as root with the superuser password and using the system administrator's menu-driven shell program, `sysadmsh`, or `mkuser`. When you have selected the appropriate option using `sysadmsh` it will invoke mkuser anyway and prompt for a user id, login name, group, password, shell and a comment. `mkuser` creates a new subdirectory in `/usr`, writes the equivalent of an MS-DOS AUTOEXEC.BAT file (`.profile` for the Bourne shell) and sends the new user some mail. There is a start of day message in `/etc/motd` and you can edit this to contain the witty message of your choice.

The i-node table is an array of 64 byte data structures. There can only be one i-node entry for each file, device and directory in the file-system. From the inode structure (`/usr/include/ino.h`) it is possible to determine everything about a file except the pathname(s) by which it can be referenced.

The i-node structure contains the following entries:



`di_mode`	File type and security keys.
`di_nlink`	Number of links currently referencing this inode.
`di_uid`	The owner's User ID number. This number is defined in the file `/etc/passwd`. It may be changed with the command chown.
`di_gid`	The owner's Group ID number. This number is defined in the file `/etc/groups`. It may be changed by the command chgrp, and is not necessarily the group number that might normally be associated with the User ID number in the previous field.
`di_size`	File size in bytes.
`di_addr`	An array of up to 10 block addresses. Files larger than 10 blocks have additional 'indirect' blocks which, instead of file data, contain a table of up to 256 block addresses. The last element in di_addr points to the first indirect block. The second to last element contains points to the second indirect block and so on. When all the elements of di_addr are used for indirect blocks, the file system doubles and then triples the size of the indirect blocks.
`di_atime`	Date and time the file was last accessed.
`di_mtime`	Date and time the file was last modified.
`di_ctime`	date and time the file status was last changed.

Figure 3 - inode

When you have finished, you type 'exit' or CTRL-D to quit from the root shell. This returns you to the login prompt. Now you login as a user and start looking around.

Exploring

When logged in as a user you are placed in a directory called `/usr/<username>`, where `<username>` is your login name. It contains three entries: `.` , `..` and `.<shellfile>`. These all start with a full stop which means that they are 'hidden' and the shell won't display them. To print the current directory type `pwd`. XENIX is case sensitive: Files called `Fred`, `fred` and `FRED` are all different. By convention, all commands and file names are in lower case. To change directories type `cd <directory>`. So far, so good. Typing `cd` by itself will take you back to your home directory. This can be irritating if you are delving deep into something and inadvertently use `cd` instead of `pwd` to find out where you are. Use `ls -l` to list the contents of directories. You can pipe the output to the `more` utility if the directory contains more than a screen full of entries (`ls -l | more`). You can DOS 'TYPE' the contents of files using `cat`, and browse them with the `vi` editor (type `:q!` to quit from `vi`).

To load a new shell, simply type its name. The bourne shell is `sh`, the visual shell `vsh` (wimps and XENIX only) and the c shell is `csh`. To log off type exit or ctrl-d. When you log off from the last shell XENIX returns you to the login prompt.

The XENIX environment is similar to that provided by the MS-DOS command interpreter. The various shells support pipes and filters which can be used to join processes. Processes are normally interrupted by hitting Ctrl-Break. The Ctrl-Alt-Del interrupt, the DOS three-fingered salute, is disabled.

Shells, like COMMAND.COM under MS-DOS, provide an interface to operating system services. UNIX and XENIX shells are much more powerful than the humble MS-DOS command interpreter and can be used to build complete batch and pseudo-interactive applications. Files containing shell commands (scripts) can be run by typing the appropriate shell and file name. In XENIX, if the first line is a colon and the permissions have been set to execute using `chmod` they will run directly from the appropriate shell prompt. UNIX executable scripts start with #! (hash bang).

When delving around you may be excluded access to a particular file. You can increase your privileges by typing `su` (switch user) and entering the superuser password.

```
#ifdef M_XENIX
#define M_TERMINFO
#endif

#include <curses.h>

main()
{
  int c;
  initscr();              /* Initialise curses */
  keypad(stdscr, TRUE); /* Enable keypad     */
  noecho();
  raw();                  /* Sashimi           */
  attron(A_REVERSE);      /* Set reverse Video */
  printw("Hello World\n");
  refresh();
                          /* Wait for Up Arrow */
  if ((c = getch()) != KEY_UP);
  endwin();               /* Reset             */
}
```

compile as follows :

```
cc <filename> -ltinfo -lx
```

Figure 4 - Using terminfo curses

Search path-names for the shells are stored in the environment space. Use `env` to display the current environment variables. The shell will only search the current directory for filenames if the PATH variables have been set to the current directory in the environment space.

When running with superuser permissions, the current directory is taken out of the search path. This is intended to stop people from inadvertently running user programs with superuser permissions. Under these circumstances, you need type '`./<filename>`' to run a program from the current directory.

The games diskette is pathetic.

File-systems

The XENIX file-system is a familiar looking place. Files are organised in tree structured directories referenced with a forward slash character, `/usr/richard/dotexe`. The basic system comes with some subdirectories already created in the root file-system.

XENIX supports mountable file-systems. To access a diskette, for instance, it should be set up as `/dev/rdsk/fd0` floppy using the `mount` command. Once mounted, the drive appears as the sub-directory `/floppy` in the root file-system. It can be removed using `umount`.

File naming conventions are subtly different from those used in MS-DOS. File names are up to 14 characters long, and may contain any character in the coded character set. There are no file extensions. By convention, executable files are kept in the `bin` subdirectory. When I first tried to run the games, they wouldn't work. I was trying to run text files. All I can say in my defence is that something called 'life' in a subdirectory called 'games' might be expected to run life.

All files have attributes, known as *permissions* in XENIX terminology. The permissions are *read*, *write* and *execute*, and are triplicated for a given file's owner, group and 'the world' ie other users of the system. If a file has its execute bit set, and is not a directory, the shell will load and attempt to run it.

Directories, because they are files, share the same permissions. To limit access to all the files in a subdirectory, you can change the directory's permissions to, say, execute for the owner only. This will exclude all other users from that directory and any subdirectories it may contain. Permissions are modified by `chmod` and permission defaults for file creation are set by `vmask`. See Figure 3.

XENIX implements UNIX file name links. A file called 'article' in `/usr/richard/dotexe` can be linked using the `ln` command to another directory entry such as `/usr/pete/xenix.arc` and two directory entries will be created pointing to the same file. Any I/O done on either link will affect the same file. As in MS-DOS, the directory entries . and .. are not files, but links to the directory and its parent respectively. When its last link is removed, a file is deleted. Thus there is no 'file delete' system call in XENIX; 'unlink' is used instead.

ed and vi

The SCO XENIX documentation deals in detail with two text editors called `ed` and `vi`. `ed`, like EDLIN, is a simple line-oriented editor from the long and noble tradition of simple line-oriented editors. If '`ed`' is short for 'editor', then '`vi`' presumably stands for 'vile'. Actually, '`vi`' is just a *nom de command prompt* for a line editor called '`ex`'. If you type '`ex`', it comes up in editing mode. If you type '`vi`', the program runs up in its visual mode. You can prove that it is the same beast, though, because if you press Esc in editing mode, it reverts to visual mode. Hit Esc in visual mode and it just beeps. There is no obvious way of telling which mode you are in, so `ex`/`vi` beeps a lot.

The red-hot UNIX editor `emacs` is available under XENIX; you'll want to get hold of a copy.

Development System

The SCO Development System consists of a command line C compiler and a modest set of tools. The C compiler that we are running (Version 2.2.1) is not ANSI compliant and does not support function prototyping.

Any programming for an interactive, screen-oriented system in XENIX or UNIX involves getting to grips with the curses library. The curses section in the Programmer's Reference lists the various functions. Figure 4 uses terminfo curses to print the BCPL compiler's historic first words, 'Hello World', in reverse video and waits for the Up-arrow key. It took me weeks to find the section in the manual that dealt with extended attributes such as reverse video (Programmer's Reference, System Services, TERMINFO).

The Development System also includes the usual `make` and symbolic debug utilities. These can be combined using `emacs` to emulate something approaching the integrated development environments available in MS-DOS.

Conclusion

In conclusion, I have two words to say to anyone who is following me down the murky path from MS-DOS to UNIX.

Good luck.

EXE

Richard Samworth is a software engineer at Software Components Limited. He is not available on any bulletin board but can be contacted by telephone on 0296 681 972. Richard was using SCO XENIX System V release 2.3.2 kid 5.52 for i80386 (RRP £675) with the Development System Version 2.2.1 (RRP £550). SCO is on 0923 816344.

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From Brobdingnag to Lilliput: Greetings!

Windows does it; Phar Lap do it; even Borland's TASMX does it. Dan O'Brien examines the emerging DPMI standard.

Protected mode and real mode have a terrible time getting on. Trapped in the same machine, they act like bitter divorcees: the big guy has all the memory, and the tiny, twisted old one hogs all the I/O. The DOS Protected Mode Interface - DPMI - is the latest attempt to get them to talk to one another. It has a lot of support: Intel, Microsoft, Phar Lap, Rational and Borland all have members on the drafting committee. Windows implements it, DOS 5 will at the very least support it, and Phar Lap's new 286 Extender is the first of what promises to be a flood of DPMI DOS extenders. But what is DPMI? And why?

Moving Swiftly on

Well, one thing it's not is 'the DOS extender in Windows'. DPMI is a much lower level protocol, and doesn't support many features which DOS extenders provide. It would, for example, require a large degree of thought to get a heavily DOS-based program running in protected mode simply by using the bare DPMI. On the other hand, if you want to write a DOS extender yourself, or an interrupt driver, or access undocumented system variables in protected mode, DPMI will provide you with the tools you need. And if you are writing a protected mode program from scratch, it might be worth considering using DPMI rather than a DOS extender, because of the finer control it allows over real/protected mode switching. DPMI, for example, will allow intensive I/O procedures to run entirely in real mode, switching modes at the beginning and end of the routine. This contrasts with DOS extenders, which generally perform the switch twice in every DOS call. And even on a 386, that can slow things down.

One ring to rule them all

DPMI's main advantage, however, is that it fills the power vacuum that has otherwise existed in protected mode. Protected mode doesn't have the anarchic structure of real mode, where programs can happily ignore operating system requirements. Protected mode was designed to have a ruler, running at the highest privilege level, allocating memory, fending off alien interrupts, and multi-tasking its children fairly and wisely. The plan was, of course, that this overseer would be OS/2. But, with most machines still running under a real mode OS, protected mode programs have had to install their own masters.

This works fine if only one protected mode program runs at a time. But there's not much room at the top, and memory managers such as QEMM and 386MAX, and extended OSs, such as Windows and DR DOS, take all that room at boot-up time. These programs take all the 386 resources, such as the memory descriptor tables and interrupt handlers, and won't relinquish them. Other, later programs, are run at a lower privilege level - too low to install their own mini-operating systems. This is why, traditionally, you could have a program to load TSRs high, or a DOS extended program, but not both. Both needed control of the machine's protected mode MMU. Quarterdeck and Phar Lap's VCPI protocol moderated

```
/* DPMI Startup code for MSC 6.0 */

#include <stdlib.h>
#include <stdio.h>
#include <dos.h>

#define FALSE 0
#define TRUE  1
typedef int BOOL;

void exitDPMI(unsigned exitCode)
{
      asm
        {
        mov al, exitCode
        mov ah, 04ch
        int 21h
        }
}

void fatal(char *s)
{
puts(s);
exit(EXIT_FAILURE);
};

main()
{
  if (!initDPMI())
     fatal("Initialisation Error");
  puts("Now in protected mode");
     exitDPMI(EXIT_SUCCESS);
}

unsigned int parasNeeded;
unsigned int parasSegment;
unsigned int is32Bits;
void (far *goProtected)();

BOOL initDPMI(void)
{
int notOk;
    asm
      {
      mov ax,cs
      mov oldCS,ax
      mov ax, 1687h
      int 2Fh
      mov notOk, ax
      mov is32Bits, bx
      mov parasNeeded, si
      mov goProtected, di
      mov goProtected+2, es
      }
if (notOk)
  {
  puts("Can't find DPMI") ;
  return (FALSE);
  }
if ( dos_allocmem(parasNeeded,
          &parasSegment) != 0)
  {
puts("Can't allocate memory");
return (FALSE);
  }

  asm
    {
    mov ax, parasSegment
    mov es, ax
    mov ax, is32Bits
    }
(*goProtected)();
return (TRUE);
```

Figure 1 - Getting into protected mode

this condition by allowing a second privileged program to cohabit with whatever took control first. It's an uneasy alliance however; both programs have the same high privilege as one another, and are constantly negotiating between themselves for control of the machine. There is still no one in absolute control, and there is still no room for a genuine protected mode multitasking operating system to take control of both.

DESCRIPTION	ENTRY	EXIT	NOTES
Entry and Exit			
These are not INT 31h calls.			
Get Current Mode	AX=1686h INT 2Fh	AX=0 for protected mode	
Get Protected Mode Entry Point.	AX=1687h INT 2Fh	AX=0 if DPMI BX=1 if 32bit CL=processor (2=286,etc) DX=DPMI version ES:DI=entry point SI=no. of paras	See Figure 1 Use XMS call to enable A20
Terminate	AH=4Ch INT 21h	Returns to launcher	Standard DOS call.
Memory Allocation			
Apart from the selector extensions in DX, these calls require and return the same values as their respective DOS calls - INT 21h, AH=48h, 49h, 4Ah.			
DOS Allocate	AX=0100h BX=para size	AX=segment or error DX=equivalent selector	
DOS Free	AX=0101h DX=selector	AX=error code	
DOS Resize	AX=0102h BX=para size DX=selector	AX=error code	
Extended Memory Allocation			
Get Free Memory Info	AX=0500h ES:(E)DI=buffer		See Figure 3
Allocate memory block	AX=0501h BX:CX=byte size	BX:CX=linear address SI:DI=block handle	No selector
Free memory block	AX=0502h SI:DI=handle		Selectors must be freed separately.
Resize memory block	AX=0503h BX:CX=new size	BX:CX=linear address SI:DI=handle	Watch out - address and handle may change!
Selector Allocation			
Allocate Selector	AX=0000h CX=# of selectors	AX=base selector	
Free Selector	AX=0001h	BX=selector AX=selector	Initial CS,SS and DS can also be freed. Use sparingly!
Convert Segment to Selector	AX=0002h BX=segment		
Get Selector Increment	AX=0003h	AX=Increment	Use with AX=0000 and AX=0100 calls
Selector Description Control			
Only descriptors of allocated selectors can be changed. Access rights and limit values can be obtained from the lar and lsl instructions.			
Get Selector Base Address	AX=0006h BX=selector	CX:DX=address	
Set Selector Base Address	AX=0007h BX=selector CX:DX=address		Use with AX=0002h to save reallocation.
Set Selector Limit	AX=0008h BX=selector CX.DX=limit		Limits > 1 meg must be page aligned.
Set Access Rights	AX=0009h BX=selector (CH):CL=access rights/type		Bits 40-55 (40-47 on 286 systems) of descriptor.
Create Data Segment Alias for Code Segment	AX=000Ah BX=code selector	AX=new data selector	
Get Descriptor Entry	AX=000Bh BX=selector ES:(E)DI=buffer		Buffer is 8 bytes of LDT entry.
Set Descriptor Entry	AX=000Ch BX=selector ES:(E)DI=buffer		
Allocate Specific Selector	AX=000Dh BX=selector		0-10h are definitely unused by DPMI host
Interrupts and Exceptions			
All interrupt code and data should be locked. The DPMI host will automatically switch to a locked protected mode stack during hardware interrupts, INT 1Ch, INT 23h and 24h. Software interrupts do not automatically switch stacks. See Figure 3 for exception stack frames.			
Get Real Mode Vector	AX=0200h BL=interrupt	CX:DX=SEGMENT:offset	
Set Real Mode Vector	AX=0201h BL=interrupt CX:DX=SEGMENT:offset		
Get Exception Handler Vector	AX=0202h BL=exception	CX:(E)DX=handler	Valid exceptions are 00-1Fh
Set Exception Handler Vector	AX=0203h BL=exception CX:(E)DX=handler		Default reflection for 0,1,2,3,4,5+7
Get Protected Int. Vector	AX=0204h BL=interrupt	CX:(E)DX=handler	
Set Protected Int. Vector	AX=0205h BL=interrupt CX:(E)DX=handler		
Protected Mode to Real Mode Communication			
All these calls use the same call structure, given here and in Figure 3. The 'flags' variable in BH should have bit 0 set to one if the interrupt controller and A20 line should be reset. This only occurs on implementations which return to real mode, rather than virtual.			
Simulate Real Mode Int. Call with Far Return Frame Call with Iret Return Frame	AX=0300h AX=0301h AX=0302h BL=interrupt BH=flag CX=Stack words to copy cross buffers ES:(E)DI=call structure	ES.(E)DI=modified call structure	
Carry flag is set on exit to indicate error or refusal for all INT 31h calls.			

Table 1 - DPMI Interface Details

This is where DPMI comes in. DPMI provides all the controls that a user application - including DOS extenders - requires in order to control memory and connect with real mode. But these programs now run at a lower privilege: they can ask for control, but they don't necessarily get it. The Global Descriptor Table - the 386 block which controls all the major system resources, like the call gates that can alter privilege levels, the interrupt tables, and the task descriptors - is now hidden away, and is accessed directly only by the host, the program which provides the DPMI calls. This could just be a DOS memory manager, or a fully-fledged protected mode operating system like UNIX, or an inbetweener, like Windows. Other programs must request from the DPMI API access to memory - and the DPMI host can refuse. The interrupt procedure is similarly controlled by the DPMI host.

The King and his pages

By now, DOS programmers may be throwing up their hands in libertarian disgust, but they may rest easy. The intimidating size of the thing (listed in Table 1) should be enough to reassure hackers, and while the system resources are carefully controlled by the DPMI server, client programs can still possess a great deal of control through the API.

A good example of the DPMI approach is in its support for the 386's paging controls. In previous times, when two programs shared control of the machine at the highest level, neither could successfully operate a virtual paging system. If one took absolute control, this left the other in a serious state of ignorance. Generally, the linear addressing that lies behind both real mode segments and protected mode selector maps directly onto the values that travel on the 80x86's address bus. But with paging, a program cannot ascertain where anything is on the bus, and so programmers wishing to access memory mapped devices are largely stuck. And there are some cases, too, when a pre-emptive paging out, or an operating system attempt to page in a segment could result in disaster. It seems obvious that time-critical interrupt handlers should never be paged out, for example. And for DPMI pagers which still rely on DOS for their file operations (like Windows Enhanced), any data that might be touched from within DOS has to remain in memory at all times, as DOS is not re-entrant. So

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DPMI provides calls for locking memory (INT 31h, AX=0600h), and mapping linear addresses onto physical memory (INT 31h AX=0800h) - as have protected mode interfaces in the past. The crucial difference between these interfaces and DPMI can be seen in how it is implemented. First, DPMI's mapping calls are *discretionary* - the DPMI host can refuse access. In more security conscious operating systems, DPMI can thus withhold access to certain areas of memory - accesses to memory mapped ports, for example. Second, the client program can *suggest* paging behaviour to the DPMI server: there is a call to inform the OS that a range of pages can be swapped to disc ahead of time (INT 31h AX=0702h). The new V1.0 of the DPMI standard has even more powerful paging controls than this. So, the DPMI host trusts the client a great deal, and the client has a great deal of control over the host's behaviour; but the host does have the final say.

Speaking terms

So what returns does a DPMI programmer get for all this sacrifice? Well, the most immediate boon is that we can now call real mode routines quickly and easily from protected mode. No less than three routes are provided, all taking roughly the same form. After initialising the DPMI system, and jumping into protected mode, the programmer sets up a structure of the form given in Figure 3, and sets the real mode values as he wishes. Then he chooses which stack frame he wishes to emulate: a simulated interrupt via the real mode vector table (INT 31h AX=0300h), IRET return frame via the CS:IP values stored in the structure (INT 31h AX=0302h), or a far return frame via the same (INT 31h AX=0301h). The DPMI changes modes, calls the routine, stores the new values in the same structure, and returns back to the protected mode routine. Simple. In fact, it can be even simpler, because the DPMI soft and hard interrupts in protected mode are now, by default, transferred (or 'reflected') to the same handlers as would run in real mode. In other words, if you do an INT 21h DOS call in DPMI protected mode, it will *do* a DOS call, in real mode, and return happily with the registers set to the real mode values. It's not entirely as simple as that, of course; there is no segment/selector translation, and, as we'll see, stack operations are a little more complex than usual, but, by and large, a client in protected mode under DPMI has much less work to do than a program which takes full control of the protected mode resources. In Figure 1, `puts("Now in protected mode")` actually works.

DESCRIPTION	ENTRY	EXIT	NOTES
Real Mode to Protected Mode Communication			
Allocate Real Mode Callback	AX=0303h DS:(E)SI=routine ES:(E)DI=call struct	CX:DX=SEGMENT:offset of address to call in real mode.	So, calling CX:DX in real mode will call DS:(E)SI in protected mode
The call back itself has the following conditions:			
	Interrupts disabled DS:(E)SI=sel:offset of real mode SP ES:(E)DI=sel:offset of call structure.	Use IRET with ES:(E)DI=Selector:offset of call structure to restore.	Remember to modify CS:IP!
Paging Control Services			
All addresses are linear.			
Lock Linear Region	AX=0600h BX:CX=start address SI:DI=size in bytes		
Unlock Linear Region	AX=0601h BX:CX=start address SI:DI=size in bytes		
Unlock Real Mode Region	AX=0602h BX:CX=start address SI:DI=size in bytes		Don't unlock memory which DOS may touch!
Relock Real Mode Region	AX=0603h BX:CX=start address SI:DI=size in bytes		
Get Page Size	AX=0604h	BX:CX=size in bytes	Usually 4 KB
Highlight Unused Page	AX=0702h BX:CX=start address SI:DI=size of bytes		Page will be placed at head of page out candidate list if demand load paging implemented.
Discard Page Contents	AX=0703h BX:CX=start address SI:DI=bytes to discard		Contents of region will become undefined
Map Physical To Linear	AX=0800h BX:CX=physical addr to use. SI:DI=size in bytes	BX:CX=linear address	A selector must be allocated to access the block
Virtual Interrupt State **Under many implementations of DPMI, interrupts will always be enabled, to allow the operating system to conduct its own servicing. However, the OS will maintain a 'virtual' interrupt state for DPMI clients, which will control whether hardware interrupts will be redirected into user routines. CLI and STI will only effect this virtual bit. PUSHF, however, will push the real processor flags to stack. These calls allow the virtual interrupt flag to be examined. Two have side effects of changing the virtual interrupt state.**			
Get and Disable Interrupts Get and Enable Interrupts Get State	AX=0900h AX=0901h AX=0902h	AL=0 : disabled AL=1 . enabled	Note that AH is not changed by these calls, so to restore the previous state, just INT 31h
Debug Registers			
Set Watchpoint	AX=0B00h BX:CX=linear address DL=size (1, 2 or 4) DH=type: 0=x,1=w,2=r/w	BX=watchpoint handle	
Clear Watchpoint	AX=0B01h		
Get State of Watchpoint	AX=0B02h BX=watchpoint handle	AX=1 : watch point triggered	
Reset Watchpoint	AX=0B03h BX=watchpoint handle		
Extensions			
Get Version	AX=0400h	AX=version BX=flags bit 0 =1 : 386 bit 1 =1 : real mode (not virtual) bit 2 =1 : virtual memory supported bit 3 =? : reserved CL=processor DH=master PIC base interruptin protected DL=slave PIC base interrupt	
Get API Entry Point	AX=0A00h DS:(E)SI=string	ES:(E)DI=entry point others=undefined	
Carry flag is set on exit to indicate error or refusal for all INT 31h calls.			

Table 1 - DPMI Interface Details (Continued)

The DPMI's use of interrupts is worth a closer look. While the interrupt handling procedure is performed within the DPMI host itself, client programs have (again) three different points in which to redirect the flow of control. Programmers can intercept the handler before it branches to real mode (INT 31h AX=0204/5h), or they can link procedures into the real mode interrupt chain via INT 31h AX=0200h. And if the interrupt was an exception, another vector chain is accessible through INT 31h AX=0202/3h.

Figure 2 explains the contortions which an interrupted program takes under DPMI. The flowchart also shows up some of the assumptions that underlie the DPMI specification. While DPMI is happy to run chunks of its client's code in real mode, it is assumed that most of the application will run in protected mode. So software interrupts whose handlers would traditionally be redirected into the core of a user program - the BIOS timer, Ctrl-C interrupt and critical error handler - are all sent into protected mode, even if they actually occur in real mode. On the other hand, other real mode software interrupts call their standard real mode routines without further redirection. Again, this reflects a DPMI assumption that real mode routines will be used for quick, standard I/O - and the faster, the better. Note that even though real mode software interrupts do not normally get redirected, the DPMI standard does provide a limited number of

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addresses, which, if called in real mode, switch to a protected mode procedure - selectable using the INT 31h AX=0303 function. Inserting the values returned from this call into the real mode vector table thus traps all interrupts, real and protected. All this however, is rather against the flow of DPMI, which expects more protected mode to real jumps, and the interface is accordingly awkward. The main niggle is that the real mode registers are frozen into the same call structure as is used for real mode calls from protected mode, and then restored when the protected mode procedure IRETs. This allows their contents to be examined and changed by the protected mode program. Unfortunately, one of the values frozen is the CS:IP, which remains at the point just *before* the protected mode call - thus sending the machine into an infinite loop if it remains unchanged. The act of popping the return value off the real mode stack (as the IRET at the end of a real mode handler would do) has to be performed manually by the protected mode handler code. Also, this structure is stored at a fixed real mode address, thus making re-entrant code a little tough to implement. And finally, real mode callbacks suffer the same problem as all protected mode/ real mode communications - the values in the real mode segment registers need references to 8086 fixed, 64KB segments, while protected mode need selectors.

Which brings us nicely to DOS extenders. They, of course, lie on the other side of the modal fence - they only need to trap software interrupts occurring within protected mode. Typically, a DOS Extender will redirect the INT 21h handler to its own routines, before the real mode handler chain is called. The extender will see every DOS call executed by the application. If the call contains a pointer reference, it will be converted to real segments, either by simple conversion (using another set of DPMI calls) or, if the pointers refer to data above the 1 meg line, by copying it down. If the DOS call refers to a buffer length above 64 KB - for instance when saving data - the DOS extender will break this down into several 64 KB blocks, calling the real mode DOS call a number of times. None of these operations is provided by DPMI, although of course implementing them with it is a lot easier than doing it from scratch.

A knack with stacks

Naturally, all this to-ing and fro-ing between modes presents difficulties, particularly in stack handling. Real mode stacks have to stay under the one megabyte line. Protected mode programs want a protected mode stack. Interrupt handlers, as we mentioned before, need a locked stack and real mode interrupts need a locked real stack. And we need yet another, high privilege stack to allow the operating system to run above all of this. Thankfully, DPMI handles most of the change overs for you, but it is important to know which stack is used when. Generally speaking, a protected mode program will initially use the old real mode stack (with the segment values in SS converted automatically to an equivalent descriptor). Naturally, the protected mode program can relocate its stack where it wishes. Switching to real mode (if the user leaves SS:SP set to zero in the call structure) brings a small (but at least 512 bytes) real stack, which is kept in the DPMI host's own real mode scratchpad area. This is always locked into memory. Callbacks from real mode and protected interrupt code run on a separate, similarly locked, protected mode stack. The old stack will be automatically reinstated as soon as the routine returns.

Getting values to cross from one stack to another is not hard: the real mode SS:SP is easily accessible once it is converted into the descriptor:offset form. This is done automatically in the realmode to protected call back, and stored in DS:(E)SI. Calls to real mode routines from protected mode which require values on the stack are catered for by using CX to set the number of words to transfer from one stack to the other. So, you push the values onto the protected stack, call INT 31h AX=030Xh with CX set correctly, and the values will be re-pushed, in the same order, onto the real mode stack before calling.

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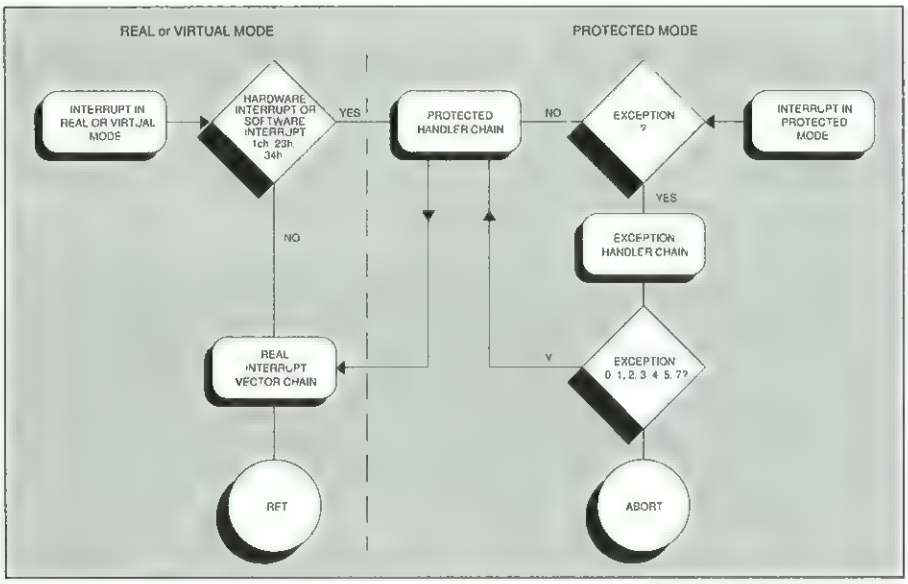

Figure 2 - Interrupt behaviour under DPMI

Malloc aforethought

Whilst communication between modes constitutes the bulk of the DPMI interface, whatever is hosting the DPMI is also controlling the descriptor and paging tables, so it makes sense to provide some simple memory allocation APIs as well. In the interests of keeping the interface low level and flexible,the act of allocating memory is kept separate in the API from actually allocating a descriptor to refer to it. In other words, in order to actually use the memory you have allocated using INT 31h AX=0501h, you must also have allocated a selector for it (with INT 31h AX=0000h) and then set the segment base address (INT 31h AX=0007h) to the linear address you originally obtained. In practice, you'll probably want to allocate a few selectors at the beginning of the program, and simply move their base addresses about, depending on which area you wish to use. A point worth noting is that the memory block itself is resized and freed through a special handle, rather than its address as one would expect.

DOS memory allocation is much simpler, returning both segment and valid descriptor in one call (INT 31h AX=0100h). For reasons of compatibility with 16-bit DPMI implementations, if the block DOS allocated is greater than 64KB in length, DPMI will set up a set of contiguous descriptors, spaced evenly apart. They aren't needed on the 386 - the first descriptor will have a limit equal to the total length so the entire block will be accessible from this selector, but it does aid in using old-time segment arithmetic. The spacing of the selectors can be found using the INT 31h AX=0003h routine. The DPMI specification warns that one 'should not make any assumptions about this value', which going by all previous standards that use this phrase signifies that it will remain eight forever.

That about covers memory management. There are a few rag-tag extra calls, mainly included to keep the DOS extender companies happy. The Allocate Specific Descriptor (INT 31 AX=000Dh) function allows a degree of control over which descriptor value you are allocated. This is so that DPMI compatible extenders can remain compatible with older versions which set aside specific selectors for memory mapped video and so on. Selectors from 0-10h are guaranteed not to be used by the DPMI host. Segment to Descriptor (INT 31h AX=0002h) allows a quickie conversion - but the selectors generated are a limited resource, and cannot be de-allocated. Generally, it is easier to change the base address of a normally allocated selector to the linear address of the area. The code segment alias descriptor call provides for the (very common) situation where the code which initialises the DPMI interface is a small bootstrap program, which then loads the main program into extended memory. To save time, a quick readable and writable duplicate of the new code segment can be made. Note that the DPMI standard itself does not specify a loading format, nor does the API have a load program call. So you'll have to write one yourself. Those interested in how it's done, complete with relocatable code fixups and so on, might like to take a swift dissassembly of the DPMILOAD program supplied with Borland's new TASMX protected mode assembler. Handily, it still has the original symbol data attached.

Watching and waiting

Three more areas of miscellany, and the standard is complete. The first is a generous donation from the DPMI host to the client: control over the 386's built-in debugging features. The debugging registers them-

Offset	Register
00h	EDI
04h	ESI
08h	EBP
0Ch	Reserved by system
10h	EBX
14h	EDX
18h	ECX
1Ch	EAX
20h	Flags
22h	ES
24h	DS
26h	FS
28h	GS
2Ah	IP
2Ch	CS
2Eh	SP
30h	SS

(a) CALL STRUCTURE FOR REAL/PROTECTED MODE COMMUNICATION

OFFSET	16 BIT
10h	SS
0Eh	SP
0Ch	Flags
0Ah	CS
08h	IP
06h	Error Code
04h	Return CS
02h	Return IP

OFFSET	32 BIT
20h	SS
1Ch	ESP
18h	E Flags
14h	CS
10h	EIP
0Ch	Error Code
08h	RET CS
04h	Return EIP

(b) STACK FRAME FOR EXCEPTIONS (INT 31h, AX=0202/3h)

Offset	Description
00h	Largest available free block in bytes
04h	Maximum unlocked page allocation
08h	Maximum locked page allocation
0Ch	Linear address space size in pages
10h	Total number of unlocked pages
14h	Number of free pages
18h	Total number of physical pages
1Ch	Free linear address space in pages
20h	Size of paging file/partition in pages
24h-2Fh	Reserved

(c) FREE MEMORY INFORMATION

Figure 3 - Structures

selves can only be accessed at privilege ring 0, but four calls provided give a useful subset of functions. The calls allow watchpoints of byte, word or double word length to be set (INT 31h AX=0B00h) or cleared (INT 31h AX=0B01). These cause an exception 1 to be generated whenever the selected memory point is written to, read from, or executed (depending on what the watchpoint was set to do). As well as calling the exception handler, the DPMI host will also mark the watchpoint responsible, and this mark can be detected using INT 31h AX=0B02/3h. Watchpoints are not, of course, restricted to debugging purposes.

The raw mode switch utilities (INT 31h AX=0305/6h) allow mode switching under conditions where the already complicated stack arrangements break down. This can occur when a routine will want to call a real mode routine, when it itself is being called by a real mode routine. As mentioned before, the 'other' mode's register state is frozen during a cross-mode call; but only in a static scratchpad store. Calling real mode again would overwrite this state. An example would be when a protected mode interrupt handler called from real mode wants to issue DOS calls. Calling them using the traditional, stack swapping method would overwrite the DPMI hosts own record of the original real mode state. In this situation, INT 31h AX=0305 can be used to obtain pointers to routines that can save these values. The real mode routine (ie that which saves the protected mode's data) is pointed to in BX:CX, and the protected mode equivalent (which saves real mode data) is in SI:(E)DI. AX returns a buffer size. To save the state, call the correct routine with AL=0 and ES:(E)DI pointing to a buffer of that size. To restore, call the same, but with AL=1. Mode switch calls which don't overwrite the DPMI host's own frozen mode values are obtainable from INT 31h AX=0306h. Executing a far *jump* to BX:CX (real mode), or SI:(E)DI (protected mode) will switch modes, but with no registers preserved. There are some continuances, however. The value of AX will be stored in the opposite mode's DS, the old CX will become the new ES, DX will be transferred to SS, (E)BX will end up in (E)SP, and the new modes program counter will start at SI:(E)DI. The (E)BP register will be preserved, and everything else will be trashed. The DPMI specification notes, incidentally, that 'applications may find functions 030Xh more convenient to use than this type of mode switching'. They weren't kidding.

Finally, everything else. INT 31h AX=0A00 takes a string pointer, and returns a pointer to any extended API of this name. This allows DOS extenders to provide extensions to the standard set of DOS calls. Phar Lap has already used this to implement its own extensions.

DPMI is certainly a firm base from which to expand. It will be seen, initially, only for its cross-mode communication features. But, by providing a set of low-level calls that all protected mode programs that wish to use system resources can use, DPMI allows a degree of central control to be imposed on protected mode systems. It also means that there is now a basic set of APIs which should exist under any protected mode operating system - DPMI can (and is designed to) work under UNIX or OS/2 memory management just as easily as it does on its own. It may not be much of a cross-system API yet - but it's a start.

EXE

The DPMI Specification is available (free) by writing to: Intel Literature JP26, 3065 Bowers Avenue, P.O. Box 58065, Santa Clara, CA 95051-8065.

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Performance tuning Paradox

Borland's Paradox has built up a good reputation as an alternative to the dBASE-alikes, but it suffers from being available only as an interpreter. Andy Redfern suggests some practical measures to speed things up.

Ansa, and more recently Borland, have taken Paradox from a nice looking idea to an excellent piece of software. They have responded to the changing hardware environments so as to support expanded memory, 386 processors and networks. They have aded VROOMM overlay technology to the package. They have also speeded up the Paradox Application Language (PAL) considerably since its first release, but still one major gripe remains - the lack of a PAL compiler.

Paradox may well provide a fine, interactive, interpreted environment for product development. But at the end of the programming when the system is complete, the developer wants a compiled version which can be sold onto the user. No one likes messing about with run-time versions and run-time licenses. Of course, the other major drawback of using an interpreted version is that the software tends to run much slower than in a compiled version. How many Paradox users have pushed the Do-It! key after typing in a query and waited and waited until you thought the machine had crashed. And just when you were about to despair the answer finally arrives. I have still to find a Paradox user who doesn't want more speed. (Mind you, that probably applies to every other package on the market, but it is especially conspicuous with Paradox.)

So while we wait for the long awaited compiler to be launched, little tips and tricks must be used to get the most out of the current version of Paradox. Of course, it needn't be said that the greatest performance benefits will be found by moving from a 286 machine to a 386 machine. Not only does the software run at a greater clock rate, but the access to the underlying PC hardware is considerably faster. But this is the real world, and often as developers we are forced to use whatever hardware platform the ill-advised or impecunious user has already bought for himself.

External Thoughts

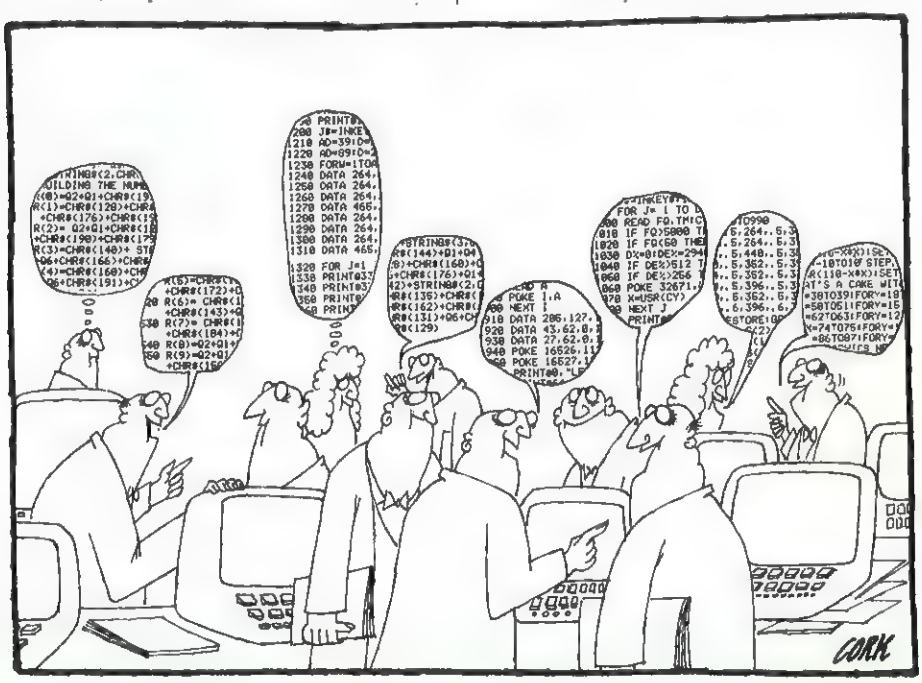
If you're upgrading your system or you are setting up a solution for a customer, there are some important points to bear in mind when choosing the hardware. On machines with 80386 and 80486 processors, the more extended memory you have the better. When installed on any other machine with a 80286 processor or less Paradox works most efficiently with expanded memory. Although Paradox will use LIM 3.2 expanded memory, greater performance can achieved by using either LIM 4.0 or enhanced expanded memory (EEMS). The speed of a DOS `BIG PAL` command can be speeded up an amazing tenfold with just 300 KB of expanded memory.

Paradox is a disk bound application by virtue of the fact that it stores all its overlay, database, script and index files on disk. A disk controller with a hardware cache like the TenTime controller will also provide a dramatic improvement in performance.

Even if you can't justify or afford to buy extra hardware Paradox can be speeded up simply by modifying the way in which you use your existing hardware.

The golden rule is this - Paradox is a database not a disk cache or an expanded memory manager. Paradox may well have the ability to cache the disk itself, but that doesn't escape the fact that it is fundamentally a database program. Therefore, if disk caching is an important performance consideration, buy a specialist disk cache program and let Paradox get on with being a database. This might sound a little harsh on the programmer who wrote Paradox's disk cache, but a few minutes' experimentation will prove the point.

It also worth pointing out that the Paradox disk cache only works on drives C and D.



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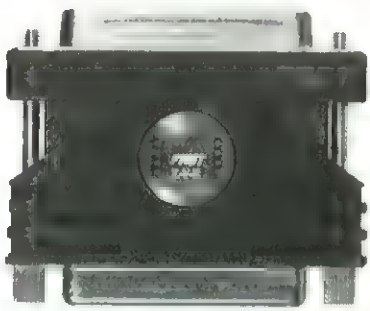

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It doesn't work on network drives, nor does it work on drives with more than 32 MB capacity. It therefore makes sense to use a cache program like PC-Tools' PC-Cache or PC-Kwik. Then in the custom setup program (type PARADOX3 CUSTOM to load it) set the percentage amount of EMS used for disk caching to zero.

In the Paradox documentation you will find that it requires 512 KB of RAM to run, but as with everything else, the more RAM you can give it in the conventional area the better it runs. On a machine with no expanded memory, the difference between 509 KB free at the DOS prompt and 609 KB free was considerable. Paradox ran around three times faster on a sort or query with that extra 100 KB of memory, and this is a major bottleneck for many users.

Paradox can be run stand alone, but many people use it on a network. In this configuration, the file server carries all the files while the local machines are kept to a minimal hardware configuration to make the multi-user system cheap to install. Once the network drivers have been installed, there is often hardly enough memory left to run Paradox as well. The answer is to use a memory manager like Quarterdeck's QEMM or 386MAX. Unfortunately, these two products only work on 80386 or 80486 machines, so you'll need a product like Quarterdeck's QRAM to get most out of the memory on a 80286 or 8086 machine.

These products all work in a similar way, allowing the user to load drivers, system files, DOS resources like FILES and BUFFERS and TSR programs into the high memory between 640 KB and 1024 KB. Exactly how the drivers are loaded high and into which areas of memory they can be squeezed will depend on exactly what type of hardware you have. Having said that, most machines have enough room to load the Novell or Token Ring drivers high.

Paradox setup

Once you have maximised the DOS memory and disk usage, we can begin looking at exactly how we set up Paradox itself.

The speed of a DOS BIG PAL command can be speeded up tenfold with just 300 KB of expanded memory

As I mentioned before, Paradox is a very disk intensive program so I recommend monitoring the program's disk access very carefully. Purely through experimentation I have found that once my hard disk falls below 96% unfragmented, performance degradation follows. This is because Paradox is having to work much harder to piece together all the files it has created. I now run Norton's Speed Disk (part of the famous Norton Utilities) on a regular basis and find the performance difference quite marked.

Furthermore, we need to monitor very carefully exactly how many files there are in each directory. In the original versions of DOS there was a limit of 128 files in any directory. To allow more files to be added to a directory supplementary file lists can be added. These have a disk access overhead associated with them. This problem can be partly improved by using the DOS FASTOPEN command. This command keeps track of the last few files that were accessed, so that if an application is repeatedly using the same files, the access time is significantly improved. The memory overhead of FASTOPEN is around 200 bytes per file. It can be loaded into high memory or in DOS 4.0 it can use the /X parameter to load itself into extended memory.

Although FASTOPEN will provide a performance improvement, the simplest way of reducing the file access overhead is to keep the number of files in any directory used by Paradox below 90. This way even when Paradox creates its own temporary files and tables during sorts and queries, the total number of files will not exceed 128. It may sound simple, but it certainly works!

Keeping the number of files in any directory below 90 is only possible providing that you use subdirectories to separate out the files, but here lies another trap for the unwary. Both DOS and Paradox can very quickly access files in directories near the top of the directory structure, but once you get more than four levels down the performance of file access once again degrades. To this end, all UNIX hackers should avoid creating directories more than four levels deep, unless you use very short directory names.

Inside Paradox

To enhance the performance of data access within Paradox, the use of indexes or keys is crucial. When you create a key field, Paradox not only spots non-unique entries, but also keeps the table of keys sorted constantly. This is a time consuming business. To make it easier for Paradox bear the following points in mind.

Keep the size of the unique keys to an absolute minimum. For example, if you need to key on a person's name, key on the surname plus a unique number, rather than the surname plus the first name and/or title. The smaller the unique key, the faster the system will run on both searches and updates. Better still, just key on the unique number. This will speed up data entry and if you need to search on the surname on a regular basis, why not add a secondary index. Hard disk space is relatively cheap after all.

The secondary indexes are created using the Query Speed Up option. This takes whatever query is currently in the work space and creates a secondary index that

Products mentioned

QEMM and QRAM are available from Quarterdeck (0245 496699).

386MAX is distributed in UK by International Data Security (071 436 2244) priced £79.

PC-CACHE is included with all versions of PC-TOOLS. PC-TOOLS Deluxe V6.0 costs £115 - details from publishers.

Central Point Software International are on 081 848 1414

PC-KWIK is bundled free on some machines (Dell for example) or is available in its latest version (Super PC-KWIK Power Pack) from Corporate Software (0734 845361) priced £72.44.

Paradox 3.5 has a retail price of £595. Borland is offering an upgrade deal to users of dBASE, DataEase, R:BASE and FoxBase of £149.95.

The Paradox Engine is available directly from Borland on 0734 320100.

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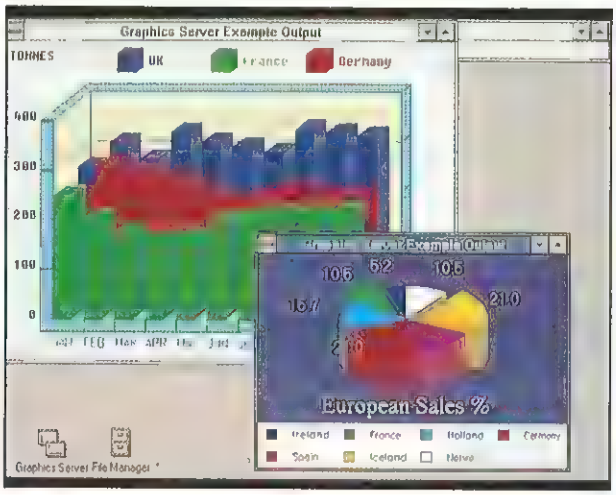

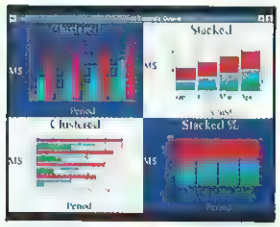

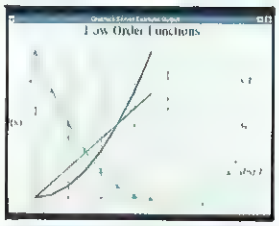

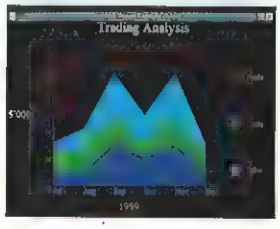

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will speed up that particular query. In a recent test with a 3 MB database, Query Speed Up managed to cut a query which took 1 minute 20 seconds down to just 12 seconds.

As your application is going through the design phase, it is worth bearing in mind that Paradox is written in such a way that databases which are 'high and narrow' rather than 'short and fat' can be searched much quicker. Put another away, keep the number of fields within a database as low as possible and don't worry about how many records you may then need to create. From the point of view of data access, it is much better to have two databases that are 80 characters wide connected by a unique key than to have a single 160 character wide database. The recommended maximum number of characters wide a database should be varies from one developer to the next, some recommend figures as low as 60 characters while others claim that there is no problem until the database exceeds 127 characters. I prefer to keep them less than 80 characters wide, but this has more to do with keeping all the data on the screen than it has to do with any proven performance cut off point.

Network Speed

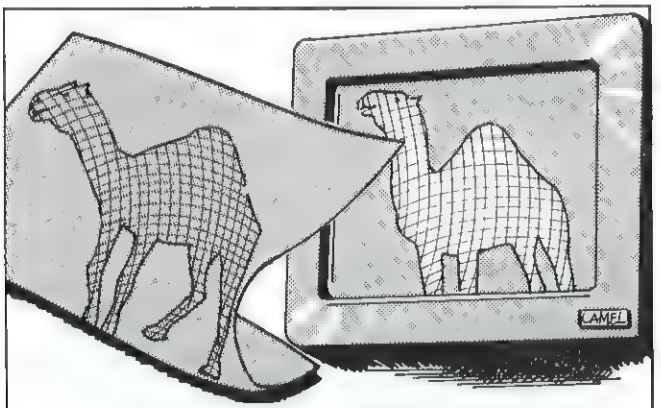
One of the major reasons that networks are so attractive to the corporate buyer is that the cost of installing 10 stand-alone PCs is considerably greater than the cost of installing a single file server and hanging 10 lower specification PC workstations off it. The problem for the Paradox developer is that remote drives, network traffic and lower specification machines all slow the application down.

Keep variable names as short as is practical, and try to spread them evenly throughout the whole alphabet

The biggest component of the network traffic is Paradox's use of overlay files. Wherever possible locate these in local storage. The overlays, help and help index take up around 1 MB, so it is feasible to use a RAM disk instead of having a local hard disk. To make sure Paradox always find its overlay files, list their location as the second item on the DOS PATH. The first item should be the location of the Paradox directory itself.

You can also locate any data files that are only used by the local user on the local machine. You could also make a copy of any data files that are read by the application but are not written to. This does have the disadvantage that a single data backup no longer saves all the data used by the application.

Another tip is to buy two machines of the same specification as the file server. This allows you always to have a reserve server in case of emergency and to have a 'power station' on the network. Then in any application you develop use the power station for any complex operations that need to be performed. Use it for complex queries, on-line back-ups and connect the network printer to it, so it runs the network print spooler as well. This



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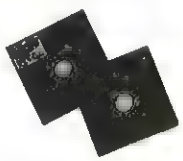

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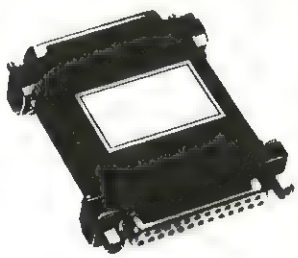

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Faster PAL

All these optimisations and performance considerations provide an excellent foundation for speeding up Paradox, but exactly how you use PAL can be the difference between a slow and fast application.

The first tip is inherent within the Paradox architecture - PAL is interpreted so all the variables and labels have to be searched and looked up on the fly. Paradox uses a simple hashing algorithm to store and retrieve the variables from memory. This means that keeping the variable names as short as is practical and trying to spread them evenly throughout the whole alphabet makes a noticeable improvement.

On a memory limited machine, almost as soon as a PAL procedure has run it is switched out of memory. Also the available resource memory can often be reduced to 0 KB, therefore making it very cumbersome to open a new image on the screen. Paradox allows you to manipulate the amount of resource memory that is left through the `SETSWAP` command. Some of the Paradox text books recommend setting this to somewhere in the region of 40% of memory left (using the `MEMLEFT()` procedure). I would rather advise that you keep it to an absolute minimum at all times. The smaller it is, the better chance Paradox has of not having to switch procedures out to disk.

How you use PAL can be the difference between a slow and fast application

Another useful swapping tip is that if a procedure is continually being switched out of memory, take it out of the library and locate it in the application itself using the `PROC` command. Then it can only be switched out of memory when you actually `RELEASE` it. Beware though, many an 'out of memory' has been generated by trying to hold onto too many of the machine's resources.

Wherever possible, try and keep the number of procedures in any library down to around 50, and aim to make every procedure as small as possible. For Paradox to make the most efficient use of its swapping, try to keep them under 5 KB in length and for best results aim for 3 KB.

If you're working on a single table, Paradox provides two mechanisms for searching for a relevant record. You can Query By Example (QBE) or you can simply `SCAN` through all the records. Surprisingly enough, in some circumstances a `SCAN` can be quicker than a QBE and it is always worth entering a piece of test code and comparing the two techniques. This seems to be especially true on tables with many, short records.

If you're using the `IF/ELSE/ENDIF` or the `SWITCH/CASE/ENDSWITCH` constructs with the `SCAN/ENDSCAN` con-

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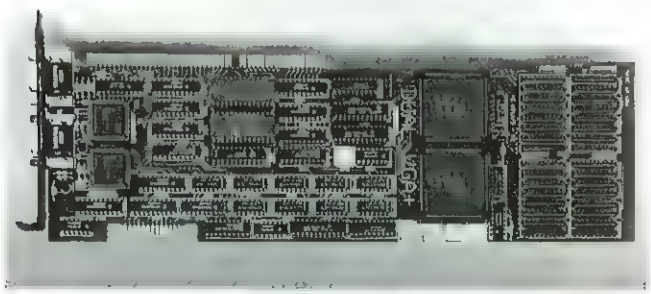

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struct, make use of the LOOP command where you can. If there are mutually exclusive conditions don't just let the procedure drop through to the ENDSCAN statement and then LOOP - force the LOOP as soon as you can. The LOOP command simply jumps back to the first line of the SCAN. You can also, where possible, use the QUITLOOP command to jump out of the SCAN once all the records you want to find have been found. Use this technique carefully though - too many condition checks looking for the QUITLOOP condition will again slow the procedure down, therefore negating any benefit of the QUITLOOP itself.

If you have experience of programming in C, then the Paradox Engine provides a neat way of speeding up time consuming routines. The Paradox Engine allows Paradox tables to be manipulated by C programs directly. Using the RUN BIG command these can then be incorporated into your PAL programs. Version 2 of the Paradox Engine, which should be available in the next few weeks, will also support Turbo Pascal and Windows programs, thus really opening up the possibilities.

Finally, it is worth reminding yourself that you are not dealing with a clever C or Pascal compiler that can spot all the standard optimisation techniques. If you want a routine to be optimised for speed you are going to have to do it yourself. No automatic shifting of invariant code out of loops here. If you're not sure of how to optimise a routine for speed, there are plenty of books on the subject of writing optimal code.

In the real world, developers are forced to use whatever hardware platform the user has bought

I really feel like I've only just scratched the surface of what you can do to make your Paradox applications faster. My final suggestion is that you get a stop watch and experiment. Many of the things I have mentioned can be improved upon simply by altering the order in which an operation is done. Queries for example, can often be optimised simply by splitting them down into simple steps.

Do also bear in mind that many of things I have suggested may not actually make any difference to the application you're writing. For example, if you have EEMS memory, the actual amount of conventional memory you have is not quite as significant as if you've only got LIM 3.2. Many operations are not actually slowed down by reducing conventional memory if you have LIM 4.0, but in all other circumstances the difference will be more than worth the effort. So get a stop watch and start experimenting.

EXE

Andy Redfern is a freelance journalist who has contributed to DESQview User, Computer Intelligence/Europe and Microscope.

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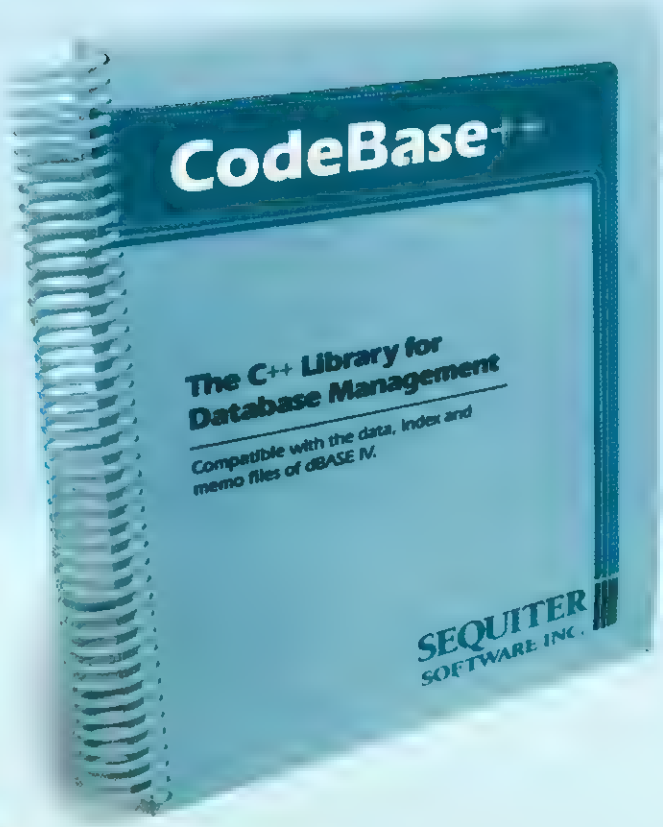

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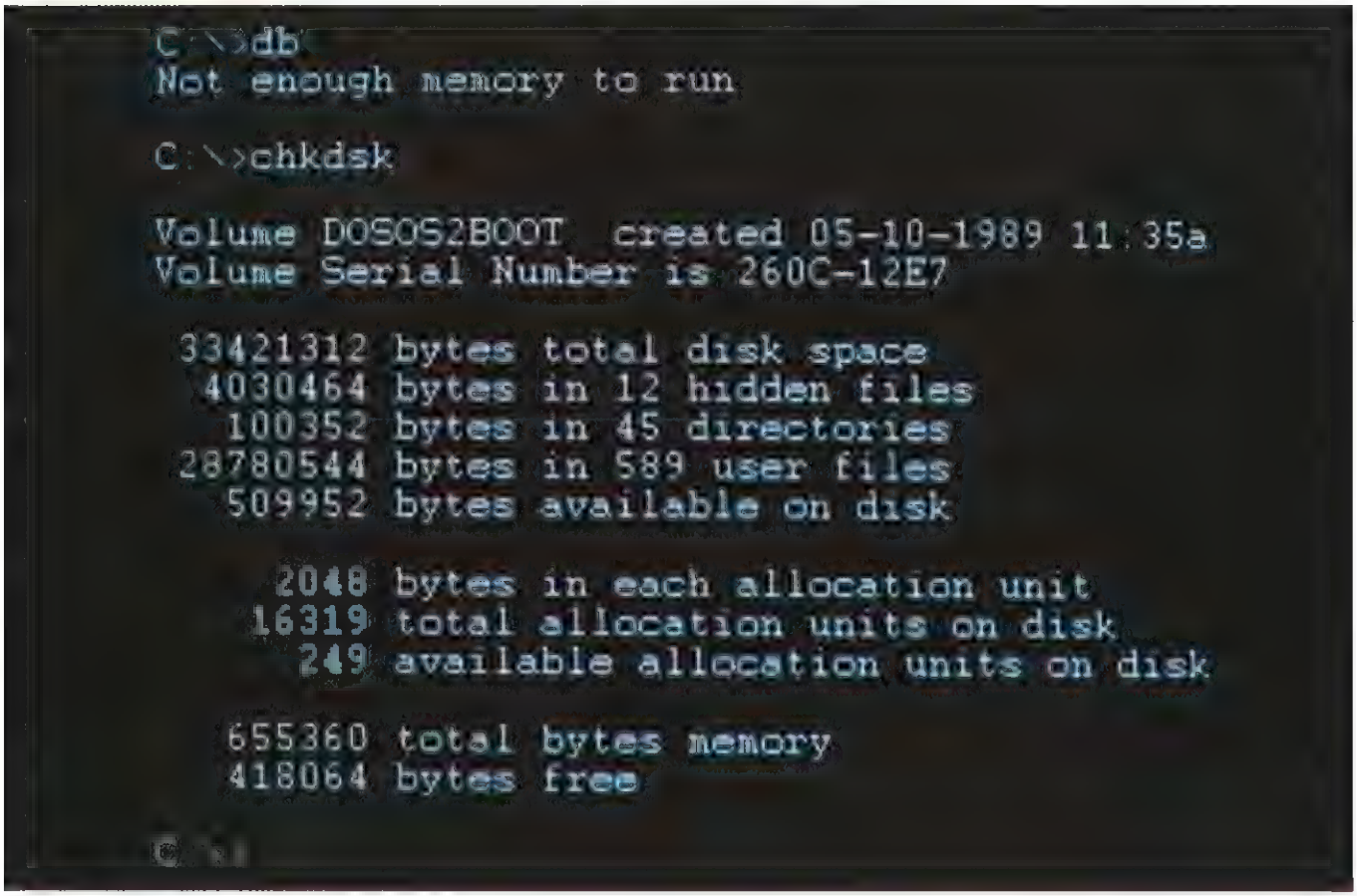

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A Canadian Solution

In the DOS world, the 16-bit Watcom C compiler is known as a solid engine that delivers fast code. Will Watts has been looking at its 32-bit cousin.

Watcom is an unusual software house. For a start, it's Canadian, its roots go back over 20 years (remember the Waterloo Pascal compiler on the college computer?), and it's successfully made the transition from big computers to little ones. If Microway's NDP software (such as the C compiler I looked at last month) is characterised by that company's go-faster hardware background, then Watcom's output has a sort of 'traditional quality software since 1425' smell to it. Watcom compilers feel like carefully-built, solid, reliable products with walnut dashes and real leather trim; when you alter a compiler switch, you half expect it to go 'clunk'.

The downside of this approach is that Watcom has been slow to adopt the windows and IDEs of modern compiler tools. If you come from a Borland/Turbo, Microsoft/Quick/PWB, JPI/TopSpeed or Zortech V2.1 environment, you are going to find Watcom tools rather primitive on the user interface. The flip side of the coin is that, presumably thanks to its experience with larger machines, Watcom has for some time led the field in optimisation technology; for example, Watcom was (to my knowledge) the first to introduce register-based parameter passing in a DOS C compiler; Microsoft and JPI have followed. Keen to retain its innovative reputation, Watcom is currently working on (for release in the summer) a 32-bit C-based toolkit for Windows and something called the 'C/p16 Compacting and Optimising Compiler'. This latter is a 16-bit DOS compiler which will use interpretive techniques to reduce considerably the size of object code. It is intended that rarely-used modules can be compiled to pseudo-object code and linked with conventionally-compiled object modules of the frequently-used stuff to produce a .EXE which is both compact and fast. (This approach must be less bizarre than it sounds: Microsoft is working on a similar system.)

I went over all the option switches, looking for the accidental 'dead slow' one that I had tripped

To the matter in hand: Watcom C-386 is now in its second major version (called 'V8.0' to keep it concurrent with its 16-bit cousin). I have been looking at the Professional Edition for DOS, which adds a protected mode version of the compiler, the VIDEO source debugger and a Profiler to the tools supplied by the Standard Edition. You also need to acquire a 386 DOS extender: either Eclipse Computer Solutions OS/386 Developers Kit, or the well-known Phar Lap 386 DOS-Extender SDK. Both systems require you to buy licences for any copies of the run-time system that you distribute with your software. Watcom's documentation leans toward Phar Lap, so I used V2.2d of that extender for this article.

The crystal box

Watcom C-386 is supplied in a beautiful Perspex box, which cracks, damnit, if you don't open the packaging *very* carefully. Documentation consists of seven spiral bound manuals: *C Language Reference, C Library Reference, Graphics library Reference, Optimizing Compiler and Tools User's Guide, Linker User's Guide, VIDEO User's Guide and InfoBench Editor.* There is also a *READ Me First* booklet, which I didn't, but came to no harm.

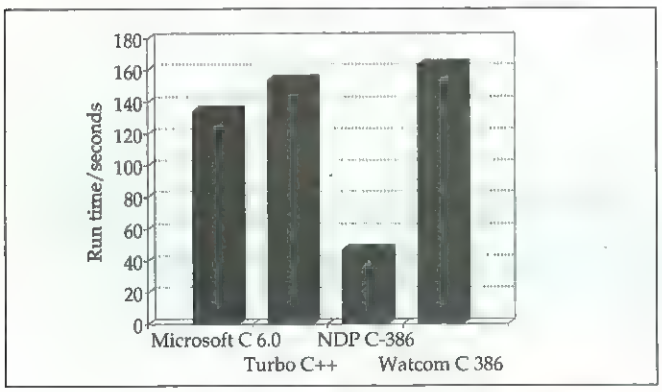

Figure 1 - Run times, including dubious NDP

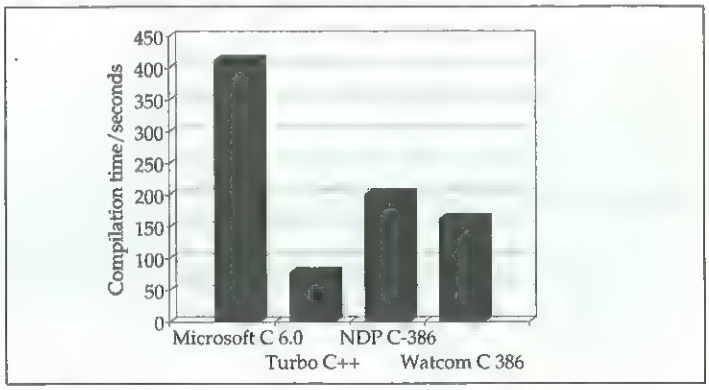

Figure 2 - Comparative compile times for Analyse

The software is supplied archived on two 1.2 MB disks which expanded to 3.6 MB on my hard disk (the complete Phar Lap toolset occupies a further 1.3 MB, but this could be reduced considerably be deleting those tools whose function is duplicated by Watcom equivalents). The INSTALL program is straightforward and unflashy, and creates a typical C compiler directory tree with separate subdirectories for binaries, libraries, includes and so on. The package includes only the 32-bit C compiler; you do not get the ordinary 16-bit DOS and OS/2 compiler, which is a pity, nor do you get the toy Express C compiler, which is no loss at all.

The compiler itself - which is command line only - is invoked by WCC386, or indirectly by WCL386; the latter is a command and link utility equivalent to Microsoft's CL. Option switches will also seem familiar to Microsoft users: for example the optimisations are turned on via a set of /o switches. The protected mode version of the compiler, supplied only with the Professional Edition of the package, is invoked as WCC386P, or by giving the /P switch to the command and link utility. As usual, C source files compile to .OBJs, which are then linked to produce .EXP files - the executable format expected by Phar Lap's RUN386 DOS extender program.

The /3r and /3s switches control the parameter passing convention. Watcom C passes its function parameters in registers by default, but there is an option switch to force it to use stack frames. There is also a complicated set of `#pragmas` which lets you set up pretty well any calling convention you like, within reason. This not only lets you do mixed language programming, it also lets you call libraries compiled for other manufacturers' Cs. A Metaware High C calling convention pragma is supplied as an example. Watcom uses these pragmas to support the `cdecl`, `fortran` and `pascal` pseudo-keywords.

Test Application

If you read my description of the Microway NDP C-386 compiler last month, you will recall that my test application consists of the calculation section of an engineering program called CADS Analyse. The CADS program performs many floating point calculations and a lot of disk I/O, see this month's *Letters* page for a critique of it as a test program. (A brief aside to address a couple of points raised in the letter. All the tests have been performed using the same floating point coprocessor, so the variance of the NDP results must be caused by the compiler. Further tests have suggested that it is the NDP software that is at fault. I chose this particular program not only to test the speed and accuracy of floating-point handling, but also to gauge the feasibility of porting a 'real' program. I'm sticking to it for the time being. Apart from anything else, I wish to retain consistency with the previous article. However, I would warmly welcome other readers' suggestions and comments, with a view to building a .EXE C compiler test suite).

Small, medium, compact and large should be mapped to flat, big, enormous and ridiculous

Porting the code to Watcom C-386 was no trouble at all, even less trouble than porting from Microsoft to Turbo C++. One reason for this is that Watcom's is the ANSI-est compiler that I've personally used (I have not tried the most recent, certificated version of TopSpeed C), passing all 79 of the Plum Hall sampler tests. Another reason is that Watcom's library contains most of the Microsoft C functions, including some graphics functions. In the end, the only code alteration that I had to do was the `#undef` and then `#define` to nothing of Watcom's `near` and `far` macros. If you think about this, this is rather surprising. Surely, I hear you say, one of the great benefits of a 32-bit compiler is that it uses a flat memory model, with 4 GB of address space into which all code and data is loaded.

This is exactly right. Watcom, however, is already worrying about the time when 4 GB won't be enough; so it has equipped the compiler to produce all the small/medium/compact/large memory models that you get with a 16-bit compiler; the difference being that a `far` pointer contains 48-bits, which gives you ample of space, just as long as you can squeeze your arrays into 4 GB each. Watcom's libraries currently don't support anything other than the flat/small model. Incidentally, wouldn't it be a good idea to devise an alternative nomenclature for these 32/48-bit memory models, to avoid confusion with their baby cousins? I suggest that small, medium, compact and large should be mapped to *flat, big, enormous* and *ridiculous*.

After minimal preparation, then, I had the test program up and working. Figures 1 and 2 give the run and compile times for Watcom, together with the compilers tested last month. In all cases, the compilers had all their optimisation switches on full. Watcom's compiler, on which I would have laid real money on coming in first, produced the slowest code of all.

This discovery was the equivalent psychological experience of looking up a favourite film in *Halliwell's Film Guide*, and finding that it had no stars and a dismissive comment. I didn't believe it. I went over all the option switches in the make file, looking for the accidental 'dead slow' one that I had tripped. It wasn't there. I phoned Watcom. The technical support bloke didn't believe it either. We went through all the switches that I had set. Everything was in order. He muttered that I/O intensive applications run more slowly under DOS extenders, because of the constant need to switch modes. True enough, but it didn't bother the Microway offering.

As you will have deduced, we have not yet found anything amiss; so Watcom's poor timing must stand. I still don't believe it, and remain in dialogue with Watcom to try to track the problem down. If anything happens, I'll let you know. By the way, Watcom got the answer right:- there were no significant differences between Watcom and Microsoft/Turbo C++ results.

Libraries

As mentioned before, Watcom's libraries are modelled closely on the Microsoft 5.1 set, and are exactly the same as those supplied with Watcom's 16-bit offering (in fact, the same manuals are supplied with both, with the occasional difference noted, such as the return of 32-bit registers from the DOS and BIOS functions). Microsoft C V6.0 extensions do not yet seem to have been included; for example, C 6.0 offers 114 graphics functions, Watcom provides just 53. Most of the missing functions are either text font handling routines (Watcom's facilities are thin in this area) or the business graphics calls, which draw pie charts, scatter graphs and so on. There is support for the CGA through to VGA graphics standards, including Hercules; but nothing for the IBM 8514/A or the various Super-VGA cards.

The library functions are contained in seven .LIB files. The main function library calls are duplicated in CLIB3R.LIB and CLIB3S.LIB,

allowing them to be invoked from programs compiled with either register- or stack-based calling conventions. Similar doubling-up occurs in the maths libraries. There are two basic sets of code; MATH387 assumes floating point instructions are generated inline, and provides an emulator (which need not be linked in if a coprocessor is a certainty) to handle FPU instructions, MATH3 - which can also use a coproc if one is detected - requires the compiler to do its arithmetic via a series of calls. There is no Weitech support. The graphics functions are held in GRAPH386.LIB, and are only supplied in 'register' mode.

Other Tools

A major plus point for this package is that there is no skimping with the add-on tools or their documentation. There is a fully-fledged make utility, called WMAKE, which seems to have more than its allotted share of options and twiddles; for example, macros to pull out the first and last of a dependency list, a heuristic algorithm for path searching and a '::' operator that lets you set up some dependency relationships that cannot be described to lesser MAKEs. It also has the occasional non-standard feature. For example, WMAKE wants the line-extension character to be & not \, which gave me a little trouble initially. Watcom justifies this by pointing out that MAKE lines that read

```
CD \
```

are ambiguous.

Unusually, the C compiler does not have an option switch to cause it to generate assembly language. Instead, Watcom provides an object file disassembler which uses debug line number information to include the relevant section of original source code as a comment to the assembly listing.

Phar Lap supplies a linker and a librarian with its DOS Extender kit, but you don't need them. WLINK the linker is a most satisfactorily versatile program. As well as supporting the Phar Lap and Eclipse 386 linking standards, it functions as an ordinary DOS linker, a Windows and OS/2 linker (including DLLs), produces Novell NetWare NLMs and can generate executables for the QNX operating system. The linker has a command line format all of its own - you'll need to alter all your response files but there is a utility, MS2WLINK , to do the conversion - but it is logical and consistent. WLINK comes paired with a librarian WLIB which can handle the same variety of object files.

The debugger, VIDEO, and the Execution profiler are privileged add-ons for Professional Edition owners only. Both are blessed with text windows + mouse style user interfaces, which in both cases are just a little quirky. The debugger is a bit like CodeView in that, despite all the windows, one is still very much aware of the command line interface underneath. This means that it takes a bit of getting into. Once there, you'll find a rich set of options and features. There are expression handlers for FORTRAN and C, all the usual watch and break point facilities, a customisable menu and an impressive set of remote debugging facilities. Remote debugging is when you run the test program on one machine and the debugger interface on another. VIDEO gives you a wide choice of hardware to join the two components: via serial ports, parallel ports, across Novell or NetBIOS networks, and even, rather surprisingly, between two DESQview windows running on the same machine.

As a prelude to running the profiler, you must first compile the test program with the debug info switch, then run it with the execution sampler. This latter program uses the clock interrupt to spring to life at regular intervals and determine the current position of the instruction pointer in your code. This information is recorded in a file. You can also place 'marks' in your source code, delimiting routines of special interest. When one of these is encountered during sampled execution, the event is also recorded in the file.

The profiler accepts this file as its input, and uses it to draw a sort of histogram of the percentages of execution time taken up by the various components of your program. When you have identified the slow bit, you can 'zoom in' down to the module concerned, then the particular block of C code, and finally down to assembly language instructions. The business of letting you scurry around your source files searching for the blockage is handled very cleverly - this tool is much easier to use than some of the earlier, non-interactive profilers you may have encountered.

I'm running out of space here, but a quick mention for text editor, which is quite simple, and vaguely CUA-ish, and loads better than my recollection of the one which used to come with Express C. It supports a mouse, simple cut and paste, multiple file buffers (using a horizontal split-screen arrangement that looks a bit primitive in these days of movable, resizable windows) and keystroke recording. If you have already wedded the editor of your choice then I doubt that this one will cause marital strife; if you are writing programs with an out-of-date edition of some fat, slow-loading word processor, then this just might be the ticket.

Documentation

Documentation is just to my taste. My taste requires that there should be many, smallish manuals, that these should be properly bound and printed (not, for example, in large; ring binders that constantly spring open), and that all information is printed out on paper - no dependence on online help databases to find the compiler switches. Actually, Watcom provides *no* online documentation at all - but as it does not supply an IDE in this package, this is no surprise. Last time I looked at a Watcom product, I commented that the documentation suffered from 'the guy that wrote the program wrote the manual' syndrome. It seems to me that this phenomenon has been largely sorted out: the text is generally clear and concise. One thing I happened to notice - a sure sign of a classy technical writing or Latin training this - is that the authors remember to use 'datum' as the singular of 'data'. Reassuring, then, to find even a small cock-up: the word 'Break' appears twice (before and after 'break point') in the index of the VIDEO manual - perhaps Watcom should have a glance under the bonnet of its index sorting program.

Conclusion

You may have detected that I am reluctant to slam Watcom for its poor speed showing. The fact is, aside from this one problem, the software was a pleasure to use. However, the compiler is marketed with an emphasis on performance. If my test code has fallen through a hole in the optimiser, then it's a big hole. Of course, the code could certainly be made to run faster by, for example, taking advantage of the multi-megabyte address space made available by the 32-bit architecture to reduce disk I/O. But this violates the rules of my original game, which was to discover the benefit of porting a DOS 16-bit C application, with minimum alteration, to a supposedly intrinsically faster environment.

In the testing of two 386 C compilers, I have found one which gives inaccurate results, and one which generates unexpectedly slow code. Hmm. There seems to be more to these big compilers than meets the eye - and there are many more to come.

EXE

Watcom is distributed in the UK by Grey Matter (0364 53499). Watcom 386 C Standard costs £515, Watcom 386 C Professional costs £680 and the Phar Lap 386 DOS-Extender Software Development Kit is priced at £370. All prices sans VAT.

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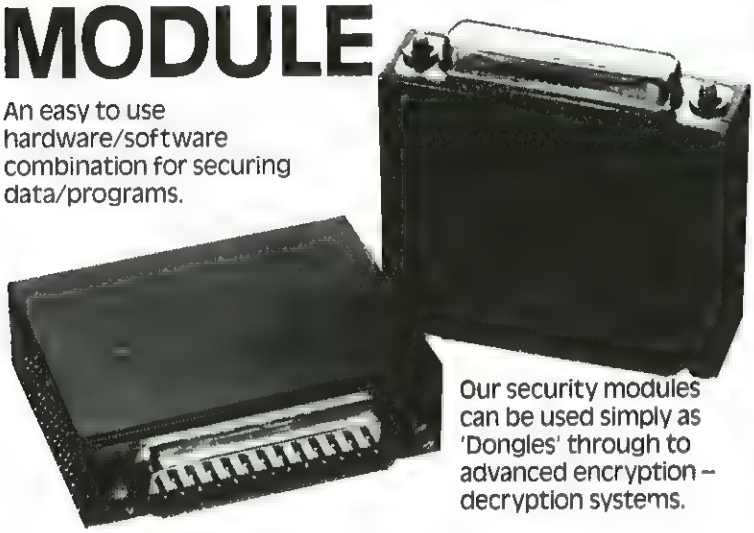

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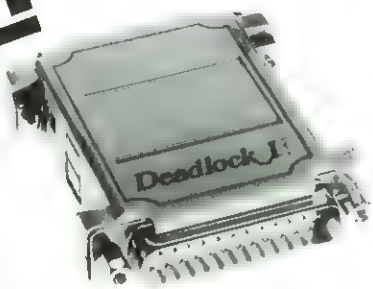

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The European AI Language with the American Name

PROLOG is a programming language based explicitly on formal logic, favoured by researchers in Artificial Intelligence. Dave Green investigates why it thinks it's so special.

They say that the language-name SNOBOL derived from its writers concluding that it didn't stand a 'snowball's chance in hell'. PROLOG, on the other hand, is widely regarded as having a much better chance of surviving a trip to mythical Hades, because that's where most people think it came from. PROLOG, more than any other computer language I've ever encountered, fits the bill as *the* mad computer language from Hell. Remember that feeling of terror and confusion when you saw your first OOP program or first had to debug extensive and uncommented C source code? Well, you're about to experience that same sensation once again, as I ask you to put aside almost everything you ever learned about procedural programming, and enter the mad mad declarative world of PROLOG.

A Scottish Evil

There's always been a fair degree of rivalry between PROLOG and LISP regarding which should be considered the language of choice for AI applications. LISP is the older of the two, having been devised in the mid-1950s by one of the American founders of the field of Artificial Intelligence, John McCarthy. On the other hand, it's difficult to trace the origins of PROLOG back much further than the late 60s and early 70s, when the idea of programming languages based explicitly on formal logical systems was being proposed by, among others, Kowalski and Hayes.

The honour of writing the first ever PROLOG program is credited to a team working in Marseilles on a natural language comprehension project in the early 1970s. However, the development of the language was due to the work of David Warren and Fernando Pereira at the Department of Artificial Intelligence at Edinburgh University. They were responsible for defining an early standard of the language, known as the Edinburgh syntax. Worldwide interest in PROLOG was kindled by the Japanese announcing that they intended to use it as the language for their Fifth Generation Computing Project. Although we don't hear so much about the Fifth Generation Project nowadays, enthusiasm for PROLOG as a symbolic high-level language continues unabated, with interpreter/compiler packages available for a variety of machines.

Predication

So what makes logic-based programming so different from the 'normal' sort? The best way to illustrate this is to give a flavour of what a PROLOG program looks like, so take a look at the listing of the standard .EXE Triangle program rendered in PROLOG in Figure 1. And then try and figure out how it works. Confusing, isn't it? While there's a superficial resemblance to function-based languages like LISP, it's by no means immediately apparent in PROLOG how arguments are passed back and forth, or indeed why certain functions (such as `input` and `displ` in this example) have been defined twice (if not more). And how come there doesn't seem to be any distinction between program and data? And for that matter, where have all the variables gone?

PROLOG programs do not consist of instructions in the conventional sense. Instead they feature what are called 'terms', which more or less correspond to logical statements about what the program effectively knows. A good example of a simple term can be seen in the first line of the Triangle program:
`number_of_sides(triangle, 3).`
This is a term (also called a predicate) which broadly corresponds to the statement that triangles have three sides and that three-sided shapes are triangles. To be more precise, it states that a possible solution (and indeed the only solution currently available) for the predicate `number_of_sides(X, N)` is `X =triangle, N = 3`.

```
%  Triangle program in PROLOG for .EXE
%  Author:        Dave Green, Mar. 1991

% Call from top level with triangle(X).

number_of_sides(triangle, 3).

triangle(Type) :-
number_of_sides(triangle, N),

write('Enter '), write(N),
write(' lengths, with .[N/L] after each'), nl,

input(N, Sides, []),
write('Triangle entered: '),
displ(Sides), nl,
!,
type(Sides, Type),
nl, write('This is a triangle of type: '),
write(Type), nl.

input(N, Current, Current) :-
length(Current, N).

input(N, End, Current) :-
        \+ length(Current, N),
%%% ('\+' is SICStus 'NOT' operator)
        read(Value),
        input(N, End, [Value | Current]).

displ([]).

displ([Head | Tail]) :-
displ(Tail),
write(Head),
write(' ').

type([X,Y,Z], illegal) :-
X >= Y + Z;
Y >= X + Z;
Z >= X + Y.

type([X,X,X], equilateral).

type([X,X,Y], isosceles).

type([Y,X,X], isosceles).

type([X,Y,X], isosceles).

type([X,Y,Z], scalene).
```

Figure 1 - The Triangle program in SICStus PROLOG

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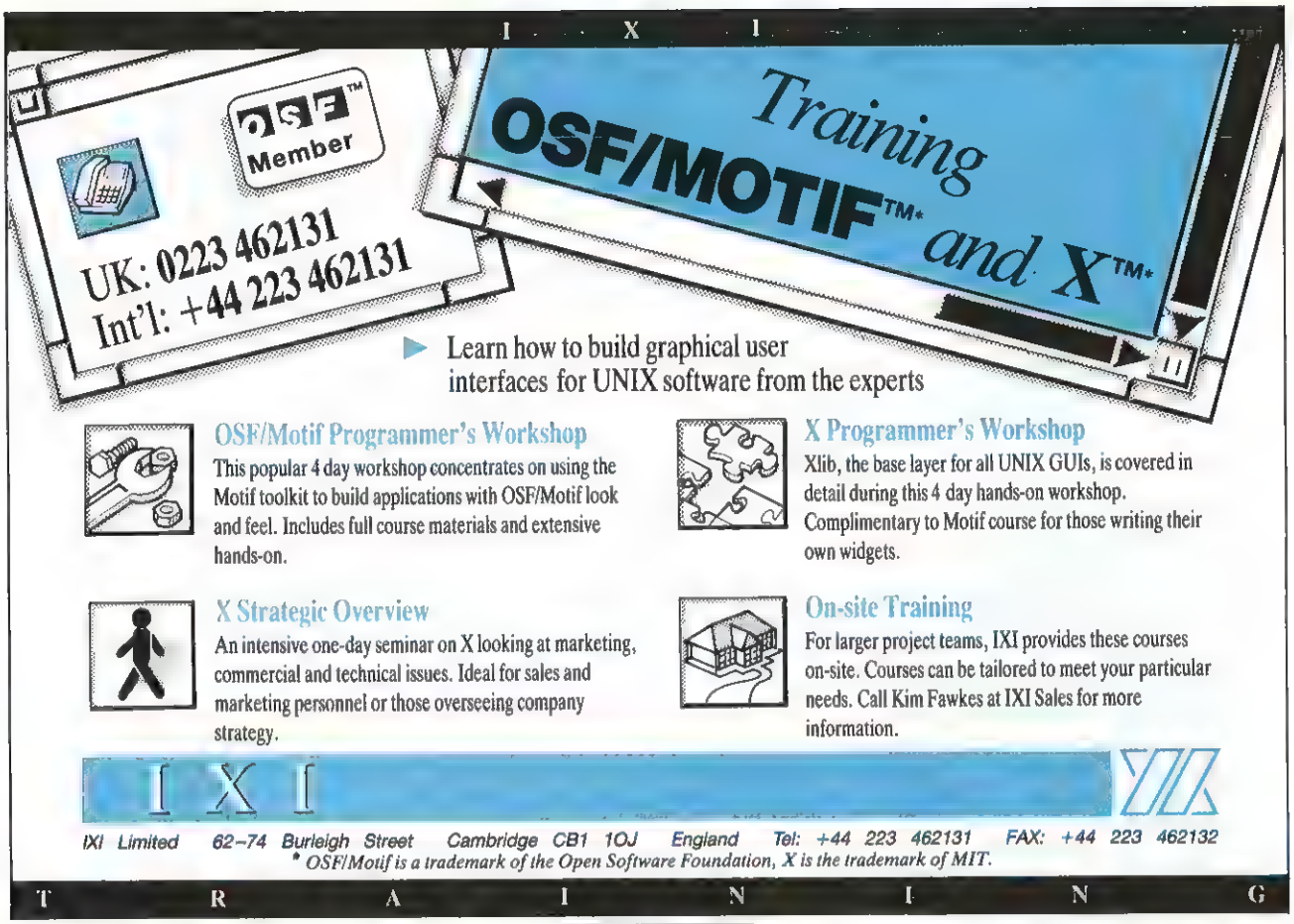

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PROLOG programs are comprised of a number of these terms stored in an order-sensitive database - 'running' a program results in the interpreter searching through this database in order to obtain the information, by means of a simple pattern-matching process. This can be demonstrated in PROLOG's interactive mode by typing in terms, and seeing whether you get a 'yes' in response (meaning that the term could be successfully proved from the database) or a 'no', meaning that it could not.

From the sample interaction shown in Figure 2, you can see that it is possible for the system to prove to its own satisfaction that triangles have three sides, and not two. And no less surprisingly, PROLOG also responds 'no' to the assertion that squares have four sides, as it will whenever it is faced with a statement which it is unable to prove from its database, irrespective of whether it happens to be true in the real world or not.

Now, suppose you wanted to make some rather more substantial enquiries about the potentially earth-shattering information the database now contains on how many sides a triangle has. To do this, you can just type in incomplete predicates with variables in the appropriate places, and PROLOG then gives you all the solutions it can find. PROLOG variables are traditionally distinguished from atoms like 'triangle' or '3' by starting them with either an upper case letter or an underscore character; as you can see from Figure 2, this approach can be used to find out how many sides a triangle has or, conversely, which shapes the system knows that have three sides, or even all known solutions to the number_of_sides predicate.

After printing out a solution, PROLOG programs wait for user input on whether to continue searching for others - hit RETURN at this point and execution will terminate with the 'yes' response indicating success. Pressing ';' will result in the search persisting for other solutions, 'no' in the example case shown meaning that no others were found.

It's a goal!

I've spent quite a lot of time explaining the basics, but that's because once you understand them, that's practically all there is to PROLOG - things just get more complicated when you start using the same logical terms to implement programmed procedures. By calling the Triangle program at top-level with triangle(X) in a PROLOG environment you are asking the program to find a value of X which satisfies the definition of the predicate triangle in the database.

However, triangle(Type) is not defined in the simple way that number_of_sides is; the ':-' operator determines that triangle(X) can only be solved if the various goals to the right of the operator can also be solved for that value of X. Successful solutions for both sides of the clause are dependent on giving appropriate values to all variables in all of the expressions given.

Now, since PROLOG attempts to satisfy sub-goals in the order in which they are found in the database, separated by either commas (representing the AND operation) or semicolons (representing OR), it now becomes possible to implement a form of procedural programming by linking together logical terms. This is how most of the predicates in the Triangle program work, and partly explains the similarity to function-based programming languages, PROLOG programs simply appearing to call predicates in a given order as opposed to calling functions.

While the difference between predicate- and function-based programming is a subtle one, it is also quite important - it is not just the case that PROLOG predicates are just LISP functions only with extra arguments. PROLOG predicates can return any number of output values, and, as we saw for the number_of_sides term, can often work in more than one direction, effectively using the arguments given as constraints defining the nature of all the solutions to be found. In this respect at least they can be considered more powerful than the simple single-value functions.

If at first...

Furthermore, LISP functions are often forced to use their single output values to indicate when they have failed, typically returning NIL. However, flow of control in PROLOG programs is kept separate from the returned values, and is defined in terms of whether a given goal has succeeded or failed. Success can mean that a solution can be found in the database for a given combination of term and variables, or, in the case of some built-in PROLOG predicates such as write, that their associated process has been carried out. Unlike LISP, the failure of a PROLOG predicate is not explicitly returned as a value.

Instead, failure to satisfy goals or sub-goals is used by the interpreter as an indication that it should backtrack to the last choice point it encountered in the program's execution, and attempt to obtain a successful solution by using any alternative options it could have chosen at that stage. For instance, adding an additional term number_of_sides(triangle, 4) to the Triangle program as given here would result in a choice point being set for the first sub-goal of the predicate triangle(Type) on execution; subsequent failure of other sub-goals would have eventually resulted in backtracking to this point and the interpreter retrying all the sub-goals with the different value of N = 4.

```
| ?- [tri].
{consulting /uhuh/prolog/tri.pl...}
{tri consulted, 259 msec 2575 bytes}

yes
| ?- number_of_sides(triangle, 3).

yes
| ?- number_of_sides(triangle, 2).

no
| ?- number_of_sides(square, 3).

no
| ?- number_of_sides(square, 4).

no
| ?- number_of_sides(triangle, N).

N = 3 ?

yes
| ?- number_of_sides( shape, 3).

_shape = triangle ?

yes
| ?- number_of_sides(X, N).

N = 3,
X = triangle ? ;

no
```

```
| ?- triangle(X).
Enter 3 lengths, with .[N/L] after each
|: 3.
|: 4.
|: 5.
Triangle entered: 3 4 5

This is a triangle of type: scalene

X = scalene ?

yes
| ?- triangle(X).
Enter 3 lengths, with .[N/L] after each
.: 1.
|: 4.
|: 4.
Triangle entered: 1 4 4

This is a triangle of type: isosceles

X = isosceles ? ;

This is a triangle of type: scalene

X = scalene ? ;

no
| ?- halt.

{ End of SICStus execution, user time
0.460 }
```

Figure 2 - Sample interaction with the Triangle program and its sub-predicates

```
employee(babbage, 20, [engineering]).
employee(einstein,30, [astrophysics, fast_cars]).
employee(edison,  15, [inventions, fast_women, loose_cars]).

earns(Employee, Salary) :-
employee(Employee, Salary, _).

has_2_hobbies(Employee, Hobby1, Hobby2) :-
employee(Employee, _, [ Hobby1, Hobby2 ]).
```

Figure 3 - Toy database using predicates as structured data

Of course choice points also occur at those stages in the program where predicates are defined more than once; while PROLOG automatically tries the earliest predicate definition first, should that one fail, it will then backtrack to that choice point to see if it has more success with any subsequent versions. This explains why there are two separate definitions of both `input` and `displ` in the Triangle program, each of which will apply under different calling conditions.

Forced backtracking to find other solutions is also what happens when the user presses ';' after PROLOG has offered a possible solution. In other words, a fully intensive run of any PROLOG program requires not only that some solutions succeed, but that all other possible solutions must fail. It is not known what effect this may have had on the world-view of veteran PROLOG programmers; we can only hope that it does not entirely counteract the gritty optimism of the PROLOG popular proverb - 'if at first you don't succeed, backtrack to all previous choice-points and continue with exhaustive depth-first search'.

There are some circumstances in which you don't want backtracking, so PROLOG conveniently gives you the '!' (or 'cut') operator, beyond which this process will not occur. This operator is used in the main `triangle(Type)` predicate to limit the solutions given to those which apply to the original input values.

Further Lunacy

The .EXE specification of the Triangle problem suggests that inputting and displaying the lengths of the sides offers the ideal opportunity to demonstrate the 'looping idiosyncrasies' of the language under scrutiny. What's most idiosyncratic about PROLOG is that there aren't any loop constructs, at least not in the traditionally iterative FOR/NEXT-type way. And so the art of devising recursive functions has been developed by PROLOG programmers to almost its logical extreme, although fortunately this is not so wasteful of stack space as you might expect since PROLOG compilers have built-in optimisers which are specifically designed to compensate. Also note the subtly different recursive structure of the predicates `input` and `displ`, required to print out the list of the triangle lengths in the same order in which they were input.

'Now wait a minute,' I hear you protest. 'If there's no iterative looping constructs in PROLOG - then how do you access arrays?'. This turns out not to be a problem for PROLOG, since it does not have arrays. Probably the most complex data structure made available by PROLOG is the list, represented by items separated by commas enclosed within square brackets. Although not as list-based as its complementary language LISP, which uses them for both data and program structures, PROLOG's use of lists once again highlights how it is intended to be a high-level language operating on symbolic information rather than mathematical formulæ. FORTRAN it most certainly is not.

All direct manipulation of lists is carried out using the '|' primitive, which separates the list's head from its tail. Given the recursion-based nature of the language, this is usually all you need, and it is quite typical of PROLOG systems to limit the number of built-in functions provided to the barest minimum - Edinburgh's SICStus system, for instance, doesn't even give you predicates to join lists together or check whether an item is a member of a list or not. While LISP packages usually come with extensive libraries of functions to do all this and more, it does seem that PROLOG has remained a smaller language in this respect.

In any case, it is doubtful how much use arrays in PROLOG would be, since, as you will have realised by now, the language has no global variables either. Fortunately this can be overcome by using data structures which are globally accessible - logical terms held in the rulebase. Figure 3 gives a short toy example of how you might construct a database for an imaginary company in the habit of employing dead scientists, complete with predicates for accessing details of their salaries and for identifying those individuals with exactly the right number of interests outside the company. PROLOG allows a number of ways of manipulating predicates as arguments, and can add and remove them selectively in the database from within the same program. This also makes it possible to write meta-predicates which can act on predicates and goals themselves, making it relatively easy to write meta-interpreters for modified versions of PROLOG or simple PROLOG-based expert system shells.

In Conclusion

The whole point of logic-based languages is to produce declarative programs which represent problems in terms of their higher-level constraints, as opposed to listing the procedure which will solve them. As can be seen from the `type` predicate in the Triangle program, PROLOG can express such things simply and economically. Unfortunately, implementing even straightforward programming procedures using the same approach can sometimes produce listings which are utterly inscrutable to anyone used to more conventional languages.

Presumably there is some sort of sinister trade-off at work here - within PROLOG it is almost trivial to write short programs to perform tasks that would take many more lines of code to implement in C, because things like pattern-matching, search strategies and even a basic grammar parser are all provided. And part of the charm of programming in PROLOG lies in trying to think in a qualitatively different way to what you've been used to when programming in other languages. After all, the idea behind backtracking isn't too hard to cope with; it's just coming to terms with it as the single control structure in your programs that's difficult. Possibly the most remarkable aspect of PROLOG as a programming language is that everything is so extraordinarily simple. Apart from the programs, of course.

EXE

Dave Green is the name of a Natural Language Front End currently being beta-tested at the Department of Artificial Intelligence, University of Edinburgh. Its areas of specialist domain knowledge include the application of psychological research data to programming problems. Communicate with this product via JANET at davidg@aipna.ed.ac.uk but please - no overlong sentences or embedded clauses.

If you are interested in reading further, it recommends Prolog Programming for Artificial Intelligence, 2nd Edition (Author: Ivan Bratko, Publisher: Addison-Wesley, ISBN: 0-201-41606-9). This contains more than you'll ever want to know about AI applications and PROLOG.

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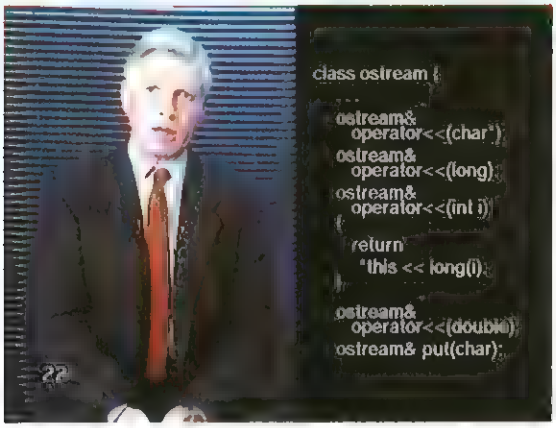

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CIRCLE NO. 691

National characters drives us mad

Denmark's Ebbe Sønderby explains the difficulties of using computers in a country where the language requires an extended alphabet.

Danish is not a language spoken or read by many people in the world. This fact is exploited by some of my coarser-natured compatriots, who feel free to comment frankly on anyone and anything they experience when travelling abroad.

Apart from the fact that the Danish language is spoken cryptography, the language is blessed with - or cursed with - three letters not normally found in English, namely 'Æ', 'Ø' and 'Å'. Æ is not all that unusual, and Å is also used in Sweden and Norway. Ø, on the other hand, to my knowledge is only used in Denmark and Norway, although it appears in the form ö in Sweden and Germany.

The Danish alphabet ends with the letters Æ, Ø and Å in that sequence. For decades, these letters were no problem; but then the computers came.

Computer standards are more or less *de facto* standards originating from English speaking countries. Though Denmark has a computer industry of its own, it certainly had no influence on ASCII. Æ, Ø and Å were completely missing, so how to use standard equipment in Denmark?

The answer was a simple one in the happy ASCII days: Z was the last letter in ASCII, followed only by the character sequence [\] or {|} for upper and lower case letters respectively. At that time [\] and {|} were not used for much in Denmark except in mathematical text books, and such books were the territory of specialist book printers and had nothing to do with computers. (The { and } are known locally as the *Tuborg parenthesis*, after the famous Danish brewery which uses a curly bracket shaped umbrella on top of its trucks. The [\] and {|} sequences were replaced by **ÆØÅ** and **æøå** in the character generators on CRTs and printers. New keytops were made. This was irritating but not difficult and everything worked out well. Eventually even the international hardware manufacturers noticed the problem, and installed DIP switches to remedy it.

Danish programmers did not have much difficulty. Since programming languages do not use the special Danish characters, software was developed on unmodified equipment which had original character generators and original English keyboards. Comments - if any - were normally written in English. Program descriptions and other documentation likewise. Only special user manuals were written in Danish, and they were typed by secretaries - on typewriters. Things were all right for a time.

The curse of PCs

Then the PCs emerged. There were Apple IIs and the other products of that time. Schoolboys learned to accept, that if you wanted a Ø, you had to type \.

Then came the IBM PC. IBM claims that the 'I' in IBM stands for 'international'. Danes know better. The correct word is another one starting with 'I' and ending with 'compatible'. Though the Æ, Ø and Å were baked into at least one of IBM's character sets, there were problems, especially with the ø.

First of all, the characters could not print on the old, modified printers. This did not matter much; buy a new IBM compatible and you were all right, except for the fact that Ø would sometimes show like Ø on the monitor and print as ¥ and ø as would show as ø and print as ¢, or the other way around. This was caused by the fact that there are two, rather than one, IBM character sets. Strange AUTOEXEC.BATs and CONFIG.SYSs including code page commands would sometimes cure this problem, but every time a new peripheral, was connected new problems would appear. Sometimes the peripheral wanted the old ASCII variant, sometimes it had the wrong IBM character set. Some packages supported ø, but didn't always print it and so on.

Then there is sorting. The sequence of Æ, Ø and Å in the Danish alphabet is not maintained in the IBM character set; normally it will sort in the sequence Å, Æ, Ø. But not always. If, for example, code pages are not used because the VGA card then shows the wrong characters, the sorting sequence in WordPerfect will depend on the code page chosen as a start up parameter. There is a tiresome and constant programming problem here; its solution is not entirely trivial.

Ø is not the only problem the Danes have. One thousand and a half is written '1,000.5' in many countries, but in Denmark it is '1.000,5'. It may seem like a small thing, but often a Dane will use an English version of a program to perform part of a task, then change to a Danish version of another program to finish it off. This means that a mental change from point to comma must be made, an almost impossible feat.

It is hard to write programs for export to other countries, and be sure that every requirement of that country is fulfilled. It is not hard to make the software flexible enough if the requirements are known, but sometimes the problems can catch you out. In this article, I have described the pitfalls in Denmark. Because the Danes are so painfully aware of the differences between Danish system requirements and other requirements, we take pride in the fact that *our* stuff is designed to be compatible with every market. I believed in this piece of received wisdom myself, until one day I had to deliver a Danish system to Portugal. The equipment included currency displays and counters for petrol tanks. But nobody had remembered that, in Portugal, currency displays and total counters to have lots of digits!

Some day, I am sure, all these problems will be over. But perhaps everyone will speak English by then...

EXE

Ebbe Sønderby graduated with an MSc in Electronic Engineering from the Technical University of Denmark in 1976. He now works as a project manager at a Danish Asea Brown Boveri subsidiary. His mission in life is to make products combining hardware and software in the best possible way.

Nil desperandum sampling...

is dog Latin for 'simulated random sampling is not to be despaired of.' Robert Loughrey takes the Code Page to a higher plane, and finds that statistics can be useful.

The final stages of data acquisition programs can be a problem. Vast amounts of dummy run test data must be generated to reassure programmer and client alike that all is well with the software, and maybe - especially if the package is an off-the-peg one - a demonstration program must be cobbled together with realistic simulated input.

For instance: external hardware - maybe an ADC reading 'real' voltages - is connected to a port of your computer. Your program module samples this port periodically, and fits the closest possible normal distribution to it (where 'closest possible' has some meaningful definition). Certainly, your client will now want to see a stream of artificial test data generated in software with known parameters to see how close your module gets, before it is integrated into the complete system. At the same time, Sales wants you to write a demo program that is interactive, and hence must 'create' fresh realistic-looking data each time it is run. They don't want to drag the ADC about with them when they go to see the clients, so again it must be done completely in software. How can these data streams be provided?

As a more camp example, your latest executive computer game simulates the stock market. You already know the *mean* of any given share or stock in any game round (ie, from its value in the previous round and from other variables representing 'rumour', 'confidence', 'annual profits', etc). Maybe you also know how bullish or bearish you want the market to be - its *standard deviation*. How can you use these statistics to generate a specific value for the commodity? The value must be *plausible*, so it will probably be somewhere around the mean (but might not be) even though it could conceivably be any value (but isn't likely to be, especially in a bearish market).

rand() has been shown to be not quite as satisfactory as was thought in K&R's heyday

These examples belong to essentially the same class of problem. One solution is to measure the heights of everyone in the office, correct the data for sex, age and race, store the distribution as a table in the program, and 'shuffle' that table before use so that it isn't, for instance, simply in increasing order. This solution is somewhat unsatisfactory. Fortunately, another solution exists: statistical simulated sampling.

The Normal distribution

It is a classical, almost philosophical, problem in science from Quantum Mechanics to Genetics to predict the behaviour of individuals from given knowledge of collectives. Usually, no certain solution exists (or is economic to find). But propositions about the probability of specific individuals behaving a certain way can be deduced from knowledge of patterns of behaviour.

If you were asked to find the pattern that your port samples or shares were to form as a whole, the answer, in all likelihood, would be something like:-

((Equation 1)) $$\frac{1}{\sqrt{2\pi}s} e^{-(\frac{1}{2})(\frac{x-m}{s})^2}$$

(usually abbreviated to $N(m,s^2)$) where m is the mean and s is the standard deviation. This is the (density function of the) celebrated *Normal Distribution* (Figure 1, where $m = 0$ and $s = 1$, should be familiar to the most 'mathophobic' reader) which captures the essence of what we mean by 'Random Behaviour'; and, indeed, thanks to a result called the Central Limit Theorem, empirical distributions from a wide range of situations tend to conform closely to the

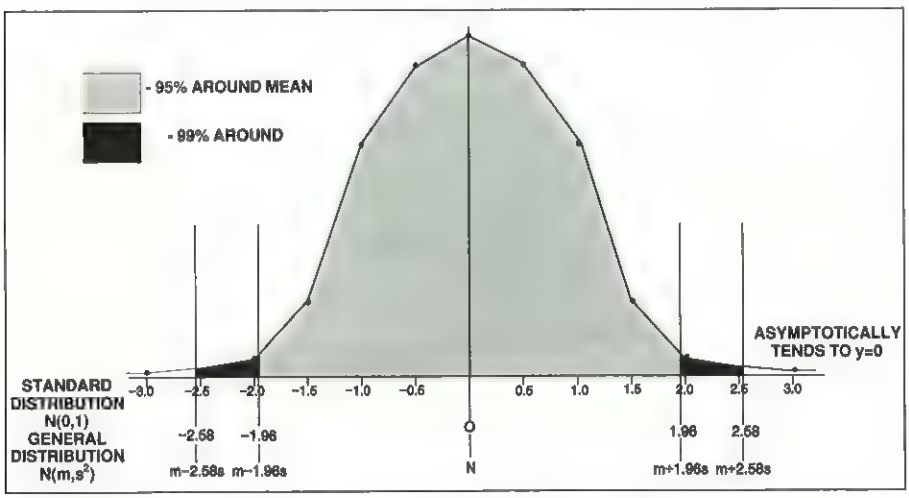

Figure 1 - The Normal distribution

above formula. So, the sizes of your friends feet, the proportion of 'heads' achieved by tossing a fair coin, and the IQs of children in a school all fit into a pattern that looks like Figure 1.

Provided, that is, the sample is large enough; you must start with a large number of friends, tosses, or children. In particular, $N(m,s^2)$ says nothing about any specific instance of a random variable. For example: you suspect, and your software is designed to assume, that your port reading follows a normal distribution with mean 0 and standard deviation 1: $N(0,1)$. Well, you can read immediately from Figure 1 that 95% of all readings will be between ±1.96. So, is the next reading from the port going to be within that range?

And did those feet

Predicting with certainty any particular value of a 'random' variable like this is, of course, no more possible then that I could correctly guess the size of your feet. But from a knowledge of your sex, age, and race, I can deduce the probability that you take a particular shoe size. For, the probability that a random variable falls within a range is given by integrating the density function of the variable between the limits of the range.

We know foot size closely fits a Normal Distribution (it is the sum of a great many Binomial - genetic - variables, and hence is Normal by the Central Limit Theorem). Suppose that the results of measuring the feet of a great many other people of your sex and age enables us to say that the mean of this distribution is 25cm and its standard deviation is 2cm. For the sake of argument, everyone with a *foot* size between 23 and 27cm takes a *shoe* size 8. Then the probability of you taking size 8 is the definite integral of $N(25,2^2) = N(25,4)$ between the limits 23 and 27, or .6826. The probability of you taking any shoe at all (including impossible ones like -3.142) is the definite integral of $N(25,4)$ between the limits -∞ and +∞; realist readers will be pleased to hear that this evaluates to 1, and to know that it will do so independent of the initial choices of m and s.

Simpson Integration

Unfortunately, it is not usually at all easy - or even possible - to evaluate these kind of integrals symbolically. Generally, they are calculated numerically. Of course, for the Normal Distribution, tables of definite integrals of the Normal density function are fairly easily obtainable; typically, these give the integral between -∞ and x for $N(0,1)$. A few values from these tables are given in Figure 7. For instance, integrating $N(25,4)$ between the limits 23 and 27 is the same as integrating $N(0,1)$ between (23-25)/2 = -1 and (27-25)/2 = +1. From the symmetry of the density function (see Figure 1), this is twice the integral of $N(0,1)$ between -∞ and 1, minus 1; or

(2 x 0.8413) -1

= .6826 to 4dps, as before (see Figure 7).

It's not really practical to store tables in a program, so your software must itself numerically integrate the density function. It is fastest to calculate any given definite integral of $N(m,s^2)$ directly; for instance, from a power series. In this article I shall instead use Simpson's Method, partly because your statistics may fit a non-normal distribution, but also because Simpson's method provides a slick, general purpose numerical integrator; something that, arguably, should be in everyone's maths library anyhow.

```
double simp(a, b, n, funct)
double a,b;
int n;
double (*funct)();
/* Integrate funct between a and b,
   using n ordinates.
   To use this code, call with (for instance)
         double x = 10.0, y;
         y = simp(0.0, x, 8, poly);
   note:
     header given in pre-ANSI form for clarity.
     Calling procedure must ensure that n is
     even & positive and that b is greater
     than a.                                    */
{
  int count;
  double sum, value, interval;
  sum = 0.0;
  value = a;
  interval = (b-a)/n;
  for(count=1; count<n; count++)
  {
    value += interval;
    if (count%2 == 0)
      sum += (*funct)(value);
    else
      sum += 2 * (*funct)(value);
  }
  sum *= 2.0;
  sum += (*funct)(a) + (*funct)(b);
  return(interval * sum / 3.0);
}

double poly(double x)
/* demonstration polynomial function */
{
  return( (3*x*x) + (2*x) + 1 );
}
```

Figure 2 - C source for Simpson integration

Simpson's Rule - after Thomas Simpson (1710-1761) - is widely acknowledged to be the best all round method of *Quadrature*, blending speed with accuracy and ease of programming. My listing for it (Figure 2) takes a pointer to a (C language) function as a parameter and is thus perfectly general; so, stick it on your utility disk and forget about it until you next need to calculate the orbit of Saturn or whatever.

Figure 2 is fairly self-explanatory, once you know that Simpson's Rule says that an ap-

Simpson of Simpson's rule

Thomas Simpson - 1710-1761 - isn't really famous for many things. Born in Leicestershire, he was a weaver by trade. In 1730 he married a woman twenty years his senior, and who would survive him, living to be 102. In 1733 he was banished from Nuneaton, where they lived, for practising witchcraft - actually a common hobby amongst men of science in those days. In London, he slowly rose to scientific respectability, and was elected fellow of the Royal Society in 1745. Between 1754 and 1760 he was editor of *The Ladies' Diary*, a kind of Georgian *Bella*. The method of quadrature that bears his name is not his only mathematical work by any means, and his general output includes tracts on calculus, geometry, experimental method and algebra. His technique was always a productive mixture of the plodding and the ingenious; yet somehow, he never again broke through from the interesting into the truly original.

```
#include <math.h>
#define PI 3.142

double normal(double mu, double sigma, double x)
/* returns the density function of the Normal curve
     N(mu, sigma-squared) at x                        */
{
/* first should really ensure sigma > 0. Then return
          exp( (mu-x)*(mu-x) / (2.0*sigma*sigma) )
          ----------------------------------------
               sigma * sqrt(2.0 * PI)              */

  double dividend, divisor;
  dividend = exp( (mu-x)*(mu-x) / (2.0*sigma*sigma) );
  divisor = sigma * sqrt(2.0 * PI);
  return dividend/divisor;
}

double stand_norm(double x)
/* returns N(0,1) */
{
  return( normal(0.0, 1.0, x) );
}

double phi(double z)
/* returns probability that the value of a
   random variable distributed N(0,1) is <= z? */
{
  if (z>0)
    return( 0.5 + simp(0.0, z, 8, stand_norm) );
  else
    return( 0.5 - simp(0.0, -z, 8, stand_norm) );
}

int scale(int n, double mu, double sigma, double x)
/* scales normal() for drawing on screen with n rows */
{
  return( (int)(sqrt(2.0*PI)*sigma*n*normal(mu,sigma,x) )
);
}

double sample(int mu, int sigma)
/* simulate a sample from normal curve
   with mean mu and sd sigma.
   Pass sigma=0 to use previously
   calculated allocations. */
{
  static int allocated[1001];
  int low, high, count1, count2, k;
  if(sigma)
  {
    low = mu - 3*sigma;
    high = mu + 3*sigma;
    for(count1=low, count2=0; count1<=high; count1++)
    {
      k = (int)(1000.0 *
        phi((double)(count1-mu)/(double)sigma));
      while(count2 < k)
      {
           allocated[count2] = count1;
           count2++;
      }
    }
    while(count2 < 1000)
    {
         allocated[count2] = count1;
         count2++;
    }
  }
  return( allocated[nrand(1000)] );
}
```

Figure 3 - C source of the algorithm

proximation to the definite integral of $f(x)$ between the limits a and b is given by:-

((Equation 2)) $$\frac{h}{3}(y_0+4y_1+2y_2+4y_3+\ldots+2y_{n-2}+4y_{n-1}+y_n)$$

The Interval $[a,b]$ has been split into n equal subintervals of width h; yr is the value of $f(x)$ at the right end ('ordinate') of the r^{th} subinterval (ie, when $x = a + rh$). It follows that $nh = b-a$.

In the listing for the function `simp()` I have passed n as a parameter. You can set this to any (positive even) integer, but values greater then 8 are starting to give more accuracy than is required, and may slow the routine down unacceptably. In addition, although increasing n obviously decreases the *discretisation* or *truncation* error - that is, the theoretical error due to the fact that, in deriving any method of quadrature, $f(x)$ is approximated by a simpler polynomial - it increases the *round-off* error - the practical problem of finite computer word size. In general, the discretisation error of Simpson's Rule will be proportional to h^4, while the upper bound on the round-off error is inversely proportional to h; so the latter rapidly catches up with and overtakes the former.

You might like to try `simp()` on the demonstration function `poly()` (integrating `poly()` between 0.0 and 10.0 ought to give you 1110.0), your own functions, or even standard calls to the maths library like `sin()` or `exp()`. Or try `simp()` on the normal equation above. Confirm that integrating $N(25,4)$ between 23 and 27, for instance, gives .6826.

nrand() and snrand()

These two functions, shown in Figure 4, replace the table of random numbers in a manual calculation, and have been lifted more or less wholesale from K&R's listing (p46 in the Second Edition). They rely on the *Linear Congruential* method - linearly transforming the last number in the sequence and dividing it modulo the upper limit of the random range to get the next. `nrand()` takes one integer parameter and returns a pseudo-random non-negative number less then that parameter. `snrand()` 'seeds' this function - it provides an initial entry point. Ideally, the parameter passed to `snrand()` should itself be a random number, although in practice using the seconds in the current minute or the ticks used in the current time-slice are both forgivable skimps.

Otherwise, the functions are used in the same way as `rand()` and `srand()` in the standard maths library. It cannot be emphasised enough that the values returned by `nrand()` are only *pseudo-random* - in fact, deterministic, but with behaviour sufficiently complex to appear random. In recent research, linear methods like those used in `rand()` have been shown to be not quite as satisfactory as was thought, perhaps, in K&R's heyday. In particular, `rand()` has an 'effective' period of only 16000, much less then was previously thought.

Lies and Stats

Figure 3 ties together all the work done so far. The function `sample()` returns a normally distributed (integer, for simplicity) value on $N(m,s^2)$, where m and s are passed

```
long int next = 1;

int nrand(unsigned int n)
/* Returns pseudo-random integer on 0,..., n-1 */
/* n >= 2 */
{
  next = next * 1103515245 + 12345;
  return( (unsigned int)(next/65536) % n);
}

void snrand(unsigned int seed)
/*  Set seed for nrand() */
{
  next = seed;
}
```

Figure 4 - C source for nrand() and snrand()

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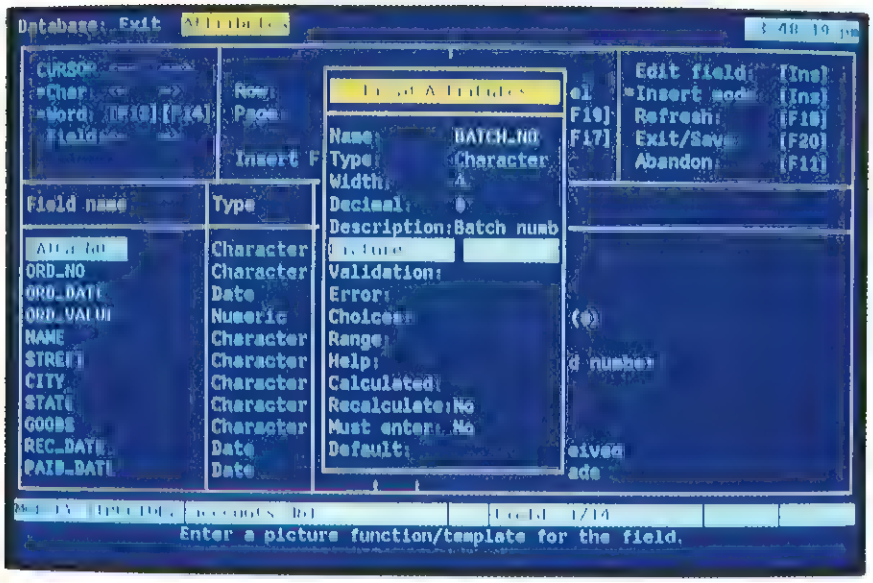

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value	standardised	integrated	allocation
19cm	-3.0	.0013	0 to 13
20cm	-2.5	.0062	14 to 62
21cm	-2.0	.0228	63 to 228
22cm	-1.5	.0668	229 to 668
23cm	-1.0	.1587	669 to 1587
24cm	-0.5	.3085	1588 to 3085
25cm	0	.5	3086 to 5000
26cm	0.5	.6915	5001 to 6915
27cm	1.0	.8413	6916 to 8413
28cm	1.5	.9332	8414 to 9332
29cm	2.0	.9772	9333 to 9772
30cm	2.5	.9938	9773 to 9938
31cm	3.0	.9987	9939 to 9987
32+cm			9988 to 9999

So, for instance, generating the random number 7345 would correspond to foot size 27cm.

Figure 5 - An example using the Normal distribution

Note: since it is not practical to integrate xI, we instead merely sum values of the density function. For instance, .0183 + .0733 + .1465 = .2381.

value	density	funct	'integration' allocation
0	.0183	.0183	0 to 183
1	.0733	.0916	184 to 916
2	.1465	.2381	917 to 2381
3	.1954	.4335	2382 to 4335
4	.1953	.6288	4336 to 6288
5	.1563	.7851	6289 to 7851 etc.

Figure 6 - An example (non-Normal distribution)

parameters. To see how it works, recall that we can deduce from Figure 7 that practically all (99.74%) of the distribution is covered by the range ±3s. We next allocate groups to each value within the range; the group number increases with increasing x, and the number of groups allocated to any value is proportional the (standardised) probability of that value being the closest to a random sample.

For example, let's follow the process with a particular distribution: feet sizes (Figure 5). As before, feet for a particular age and sex are normally distributed with mean m = 25cm and standard deviation s =2cm. So 99.75% ('all') of measured samples fall in the range x_i = 19 to 31cm. Standardise each of these values - map from $N(25,4)$ onto N(0,1) - by replacing with $y_i = (x_i - m)/s$ = -3, -2.5, -2, ..., 2.5, 3. Next integrate N(0,1) from $-\infty$ to y_i, giving .0013, .0062, ..., .9938, .9987. These form the basis of our allocation, 0 to 13, 14 to 62, etc.

For speed all the above is done only once for each distribution, then stored in the static array `allocated[]` (pass `sigma != 0` for `sample()` to re-evaluate the array). So, for instance, in the above

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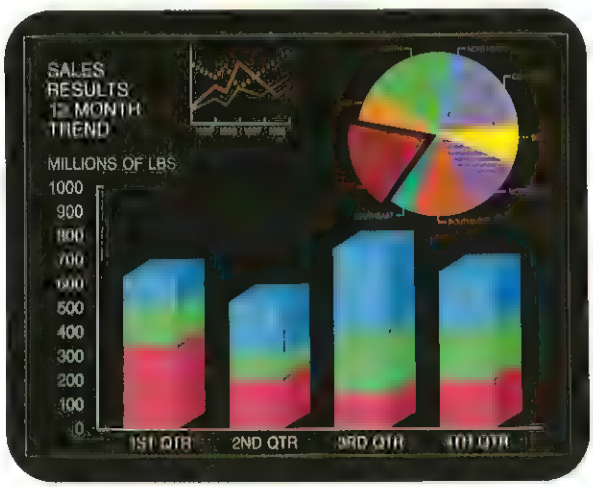

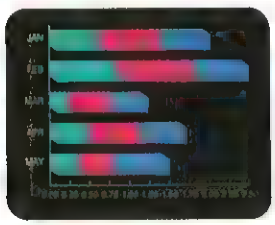

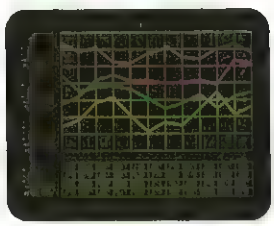

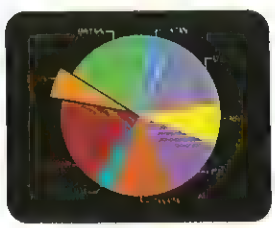

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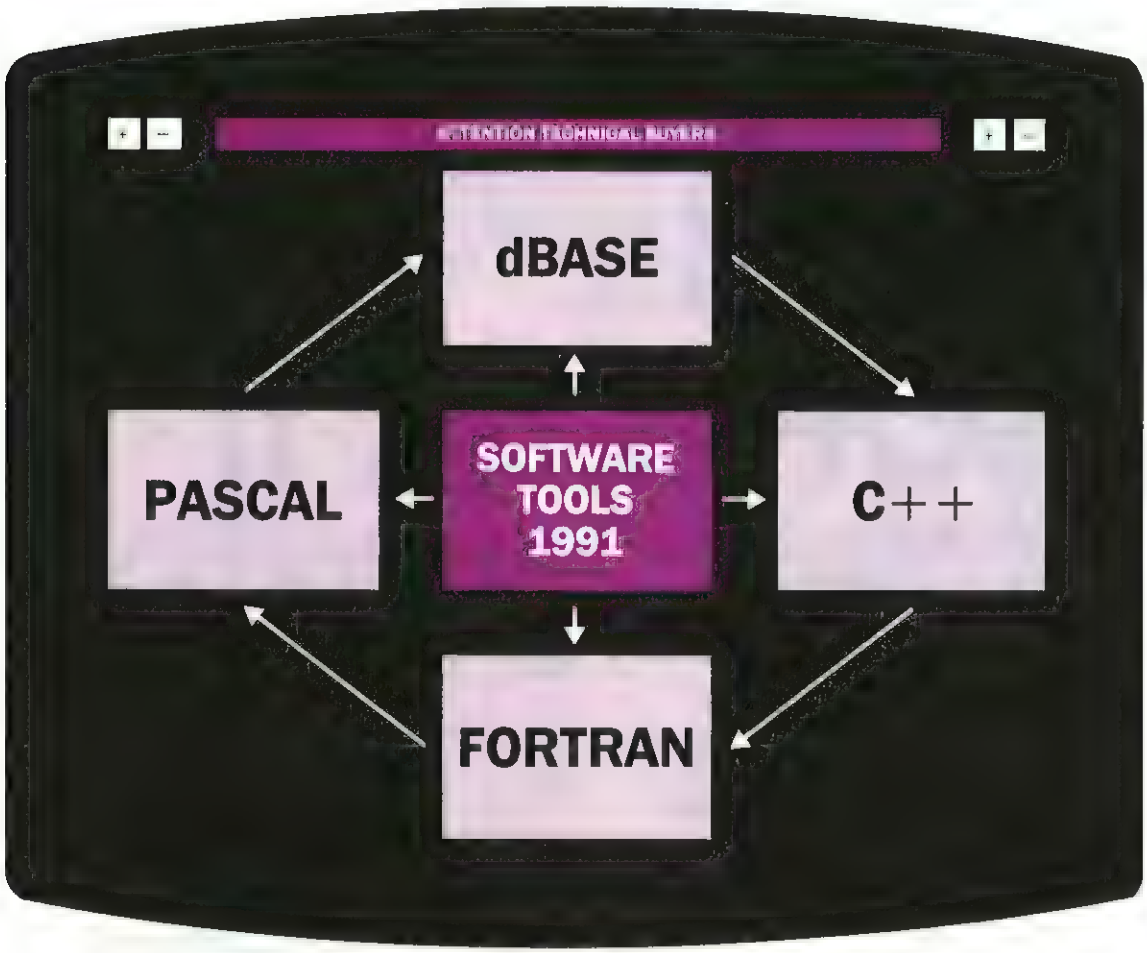

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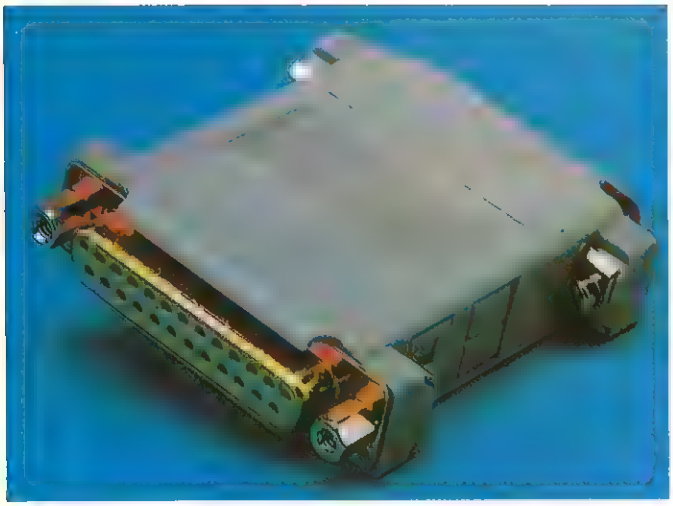

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0.0	.5000	
0.5	.6915	
1.0	.8413	
1.5	.9332	
1.96	.9750	(95% around mean)
2.0	.9772	
2.5	.9938	
2.58	.9951	(99% around mean)
3.0	.9987	
3.09	.9990	(99.9% around mean)

Figure 7 - Some entries from standard tables for N (0, 1)

example, `allocated[0]` to `allocated[13]` is 19, `allocated[14]` to `allocated[62]` is 20, and so on. Then we need only generate a random number between 0 and 999, and index `allocated[]` to find a normally distributed random value between 19 and 31.

As a final example, let's consider the algorithm built into `sample()` in the case of a non-normal distribution - say the Poisson Distribution:

((Equation3)) $$\frac{e^{-m}m^{x}}{x!}$$

This curve fits so-called 'rare-events', such as 'phone calls arriving at a switchboard. For instance, to model buses arriving at the bus stop outside my house (certainly a rare event), we first find (by experiment or by consulting the timetable) how many buses we *expect* to arrive in a typical unit time interval - say an hour. Suppose four buses, on the average, arrive every hour. Then we can simulate the situation with the Poisson Distribution P(4). The solution is given in Figure 6. As before, once the groups are allocated, we need only generate a random number to produce a sample that is indistinguishable from a real experiment.

Figure 1, the celebrated Normal Distribution, should be familiar to the most mathophobic reader

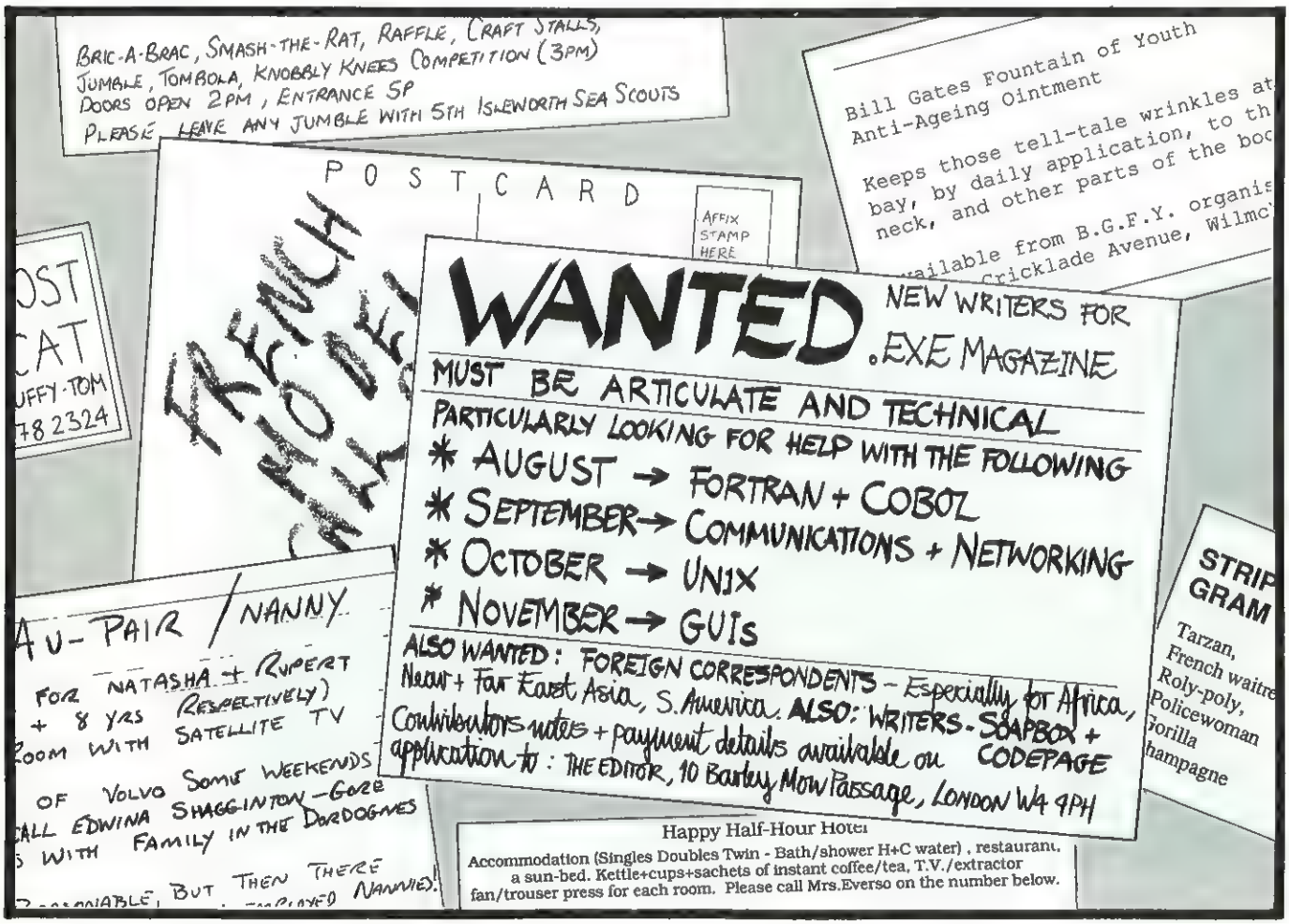
Discussion

According to John Allen Paulos (*Innumeracy*), the science of statistics originated in 18th Century mortuaries, and has never succeeded in throwing off that grim image. In contrast, probability theory was born in the illicit, Bohemian gaming houses of the period, and to this day has a sexy image that has always escaped its less dashing cousin. Certainly, the latter has had a dreadful press; not helped, I believe, by typical uses of the subject in fields such as psychology.

But there is life in the old subject, and used imaginatively it is a vital tool for all scientists and engineers. The fundamental problem with statistics as a science is that it cannot tell you anything you didn't already know; but, like stepping back from a painting, it can reveal truth from what at closer inspection appears mere randomness.

EXE

Robert Loughrey is a writer and engineer living in Sussex. *The author would like to thank John E. for his help in the preparation of this article.*



DOS on UNIX

Our UNIX expert Peter Collinson acknowledges that DOS has its uses, but he doesn't want to clog up his office with a PC, so he has found a software alternative.

Why on earth should you want to run MS-DOS programs on UNIX? Isn't UNIX good enough? Can't you do everything that you would want on UNIX? Everyone seems to pass through a religious period where their system or editor is the only thing worth using in the world. By definition, everything else is complete rubbish. I guess I have got past this with UNIX. I occasionally need to run and develop MS-DOS programs. Also I sometimes want to bridge the gap between the tools that live in the UNIX world and those in the MS-DOS world. These occasions are few, but they happen.

For example, this article is written on a Sun SPARCstation 1+ using a UNIX editor. Our illustrious Editor prefers me to submit things in a form that he can read electronically. So for the final stages of article preparation, I import the text into Microsoft Word running on a program that emulates an MS-DOS machine. I use SoftPC from Insignia Solutions; it runs on a variety of machines and emulates a PC/AT. After some editing, I place the golden words on an MS-DOS format floppy. The floppy is mailed to the .EXE office and injected into the publishing system that is used there (Ventura). SoftPC means that I don't need additional chunks of hardware littering up the place. I can run MS-DOS programs on a UNIX machine.

SoftPC

What exactly does SoftPC do? It's an emulator of an IBM PC/AT containing an Intel 80286 CPU and an 80287 maths coprocessor. It only emulates real mode operation of the CPU - it does not support the 286's protected mode. When the program is started, the emulated machine bootstraps MS-DOS 3.3. It accesses a file in the user's home directory to emulate the battery backed-up CMOS RAM chip installed in the PC/AT. The PC/AT comes with 640 KB of memory and has the ability to add up to 32 MB of expanded memory using LIM Revision 4. This is not part of the address space of the program. It is simulated by creating a file in the same directory that SoftPC is started.

SoftPC runs under the X window system on various platforms. The look of the display on my Sun is shown in Figure 1. I have a monochrome SPARCstation 1+ and run X using OpenWindows, version 2. The example shows the OpenLook window manager, which supplies the border around the display. There are two areas to the window. The large area represents the screen of the PC. The small area to the right contains: the SoftPC logo, some buttons for turning features on and off, and an information area that tells you the keyboard state and what type of graphics emulation you are currently using.

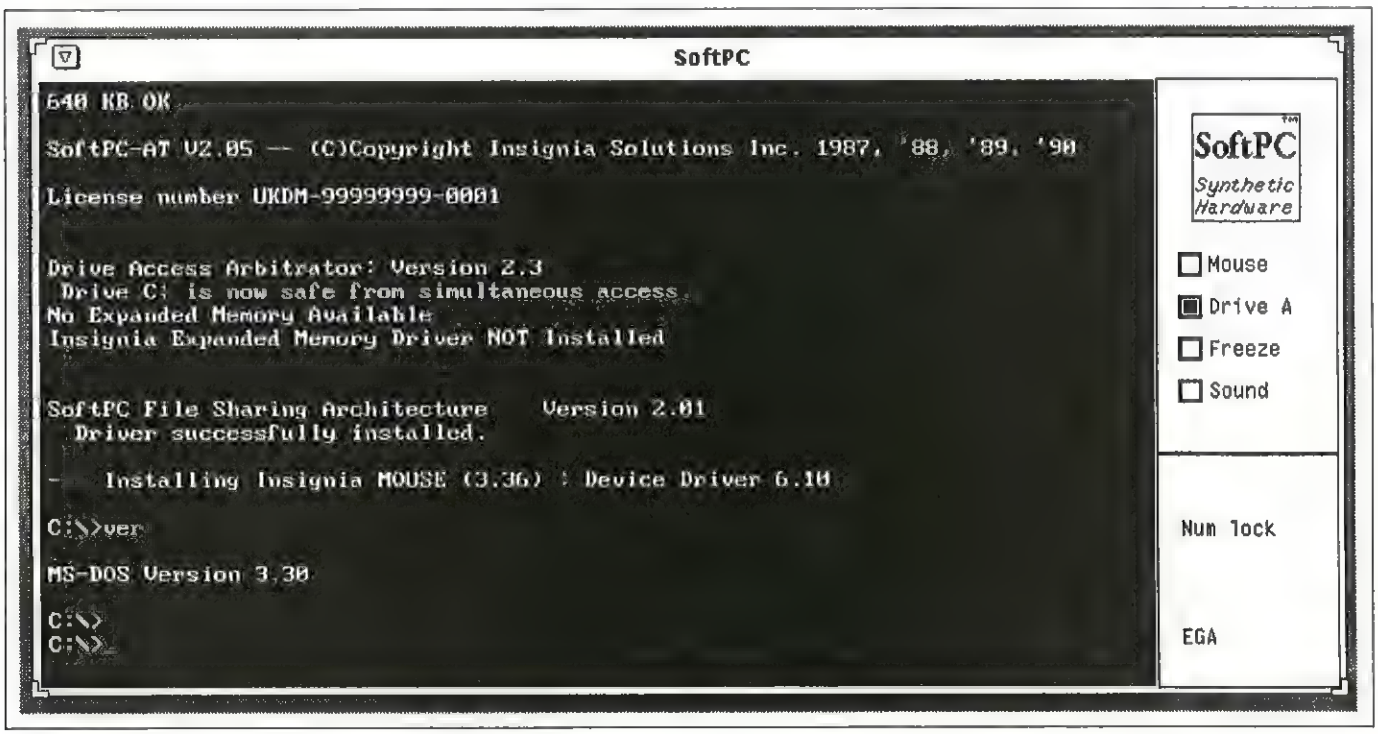


Figure 1 - The SoftPC PC/AT screen just after bootstrap

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SoftPC emulates three types of graphic adaptor on the X window screen: EGA, CGA and Hercules. It is easy to switch between the display forms - you make a quick menu selection. This forces the emulated PC/AT machine to reboot, the window resizes and you have a new adaptor in place. I have not managed to use SoftPC running on a colour screen, so I cannot vouch for the colour mappings that are supported. Monochrome screen usage is fine and is actually better that the previous PC emulator that I owned, `vp/ix` running on a Sun386i.

SoftPC can access the floppy in the SPARCstation as PC/AT drive A. Look again at Figure 1. The small square box next to the lettering 'Drive A' is a button that is clicked on by the mouse. The black square means 'on', the drive is enabled and attached to the program. Pressing the button, by pointing the mouse cursor and clicking, will eject the disk and detach the drive from this copy of the emulation. You can attach the drive to another running copy of SoftPC by pointing with the mouse at the relevant button and clicking. If you boot SoftPC with a disk in the floppy drive then it behaves as you might expect: it thinks that the disk is a boot disk and tries to load a system from the floppy.

The 'Freeze' button stops the PC emulation dead in its tracks, and allows you to see what is happening in the machine. The 'Sound' button enables or inhibits the PC's ability to beep at you. The program does not emulate all the sound capabilities of the PC. Finally, the 'Mouse' button affects the mode of the mouse. With the button off, the PC ignores any mouse actions in its display window. The mouse is apparently inoperative if you fire up MicroSoft Word or Windows. Hitting the 'Mouse' button on the SoftPC facia will turn on the PC mouse emulation displaying the appropriate PC cursor shape. Sun machines have a three button mouse, and the left and right buttons map onto the PC's normal two button mouse. The centre button brings up a menu of options allowing you to configure SoftPC and alter its actions - see Figure 2. You can always use the centre button, and you need to. It's the only way of getting the mouse back when SoftPC has grabbed it after you have pressed the Mouse selection area on the facia.

Why on earth should you want to run MS-DOS programs on UNIX?

Disks

SoftPC needs to support a DOS hard disk because many programs expect to find one living at drive C. The hard disk is emulated by creating a MS-DOS file system in a single UNIX file, usually called `hard_disk` on your home directory. The location of this file is configurable, as is its size, which can be up to 32 MB.

You can have two of these MS-DOS file systems in different UNIX files attached as drives C and D should you desire. I haven't bothered. You can also add a RAM disk, which is a big speed win.

In addition, you can make the files in your UNIX file system pop up in the MS-DOS file system by using what Insignia call *File Sharing Architecture (FSA)*. This allows you to associate a directory in the UNIX tree with an MS-DOS drive. The files in the UNIX directory then appear to be placed on the MS-DOS drive when accessed from SoftPC. All normal MS-DOS operations will work on the files, and you can move down the file system using the MS-DOS `cd` command.

UNIX files can be named using any string of characters, but DOS file names are limited to an eight character stem and three letter extension. For things to work nicely, SoftPC needs to convert between these two standards. As it turns out, the conversion is reasonably natural. UNIX files that fit with MS-DOS naming conventions appear with unchanged names. Files that don't are altered so that they are accessible by MS-DOS having a name that resembles the original name. The rules are given in full in the SoftPC installation guide. Files created by MS-DOS are written with a lower-case name on the UNIX directory.

There is one standard FSA connection that is tied to drive E and is configured from the internal setup menu summoned by the centre button. You can add extra FSA drives by editing your `autoexec.bat` to contain lines like:

```
net use h: /home/pc
net use p: /home/pc/pc
```

This attaches drive H to my home directory (`/home/pc`) and drive P to the sub-directory where I store all my PC related programs and data. I tend to keep various compilers and window system on the UNIX disk rather than in a MS-DOS file system, largely because it is easier to delete and compress things.

Moving text files from UNIX into MS-DOS is a bit painful. UNIX ends its lines with a single newline character, while MS-DOS ends its lines with a pair: carriage return and line feed. In addition MS-DOS sometimes likes to place a control-Z character at the end of the file. Insignia supply two programs: `unix2dos` and `dos2unix` that are used to move text files easily between the worlds. You are given both UNIX and MS-DOS version of the programs. It is a little annoying that the UNIX versions cannot be used as filters, taking their input from standard input and writing output to standard output.

Other peripherals

SoftPC emulates two serial devices `COM1/COM2` and two parallel devices `LPT1/LPT2`. These can be connected to files, real devices or pipes. The pipes allow output from SoftPC into programs, so it is easy to make the printer on the emulated PC drive the printer spooler supported on SunOS.

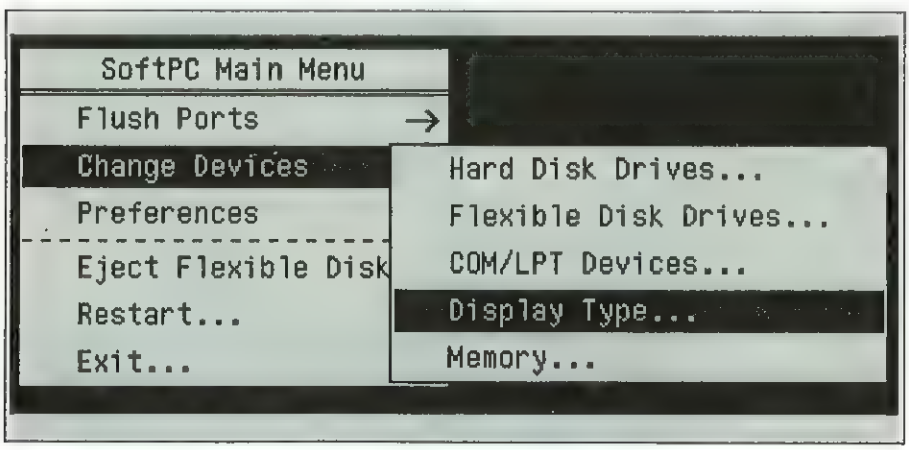
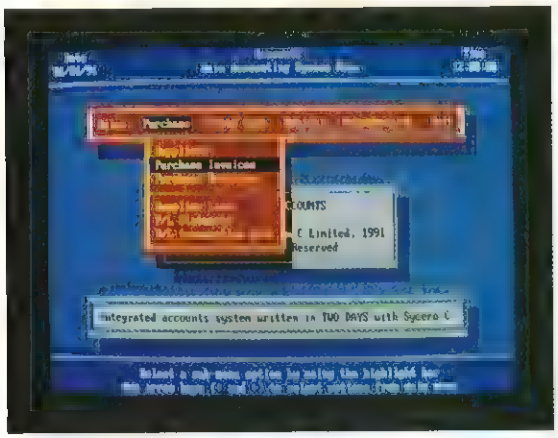


Figure 2 - The SoftPC main menu, summoned by the centre mouse button

SoftwareDevelopers!



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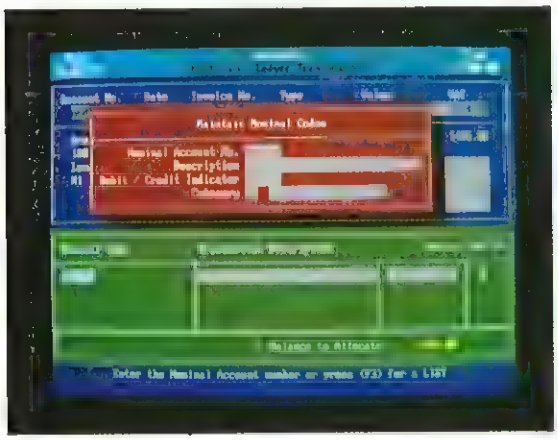

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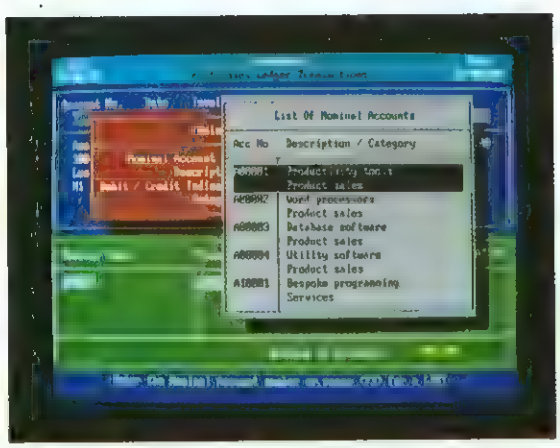

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It can be a bit fiddly to drive a PostScript printer because most printer spooler software demands a proper PostScript preamble. Also it will not expect to receive the PostScript end of job marker (Control-D). The PC is unaware of these problems and will happily think that it has complete control of the printer. I have found that piping output from SoftPC through the following shell script eliminates most of the problems:

```
#!/bin/sh
(    echo '%!From dos'
   tr -d '\004\032\015'
) | lpr
```

The piece in round brackets prints the string, and then uses `tr` to copy standard input to standard output deleting any Control-D, Control-Z and carriage returns that it finds. All this is fed into `lpr` to send the file to the printer.

Efficient printing is an area of great technical difficulty for the emulator. It is hard for a program to deduce when to close the file and terminate the pipe. The setup menu provides a way of forcing data flush, so the operator can force things to happen.

Installation

SoftPC comes on a single 60 MB cassette. Installation is painless, you just need 6 MB of available disk and a knowledge of how to run `tar`. The installation process comes with a license number that you need to type into a special program.

The 'Freeze' button stops the PC emulation dead in its tracks

You do need to be running OpenWindows 2 supporting an X windows environment on your workstation, but you should be doing this anyway so this is no hardship. The program comes with its own X fonts that you need to inform your X server to use. Finally, there is an X resource control file that is installed in the usual place:

`/usr/lib/X11/app-defaults`.

Each user who will use SoftPC then needs two initialisation files placed in their home directory. The first, called `cmos.ram`, hosts the start-up data for the ROM in the emulated hardware. The second, `.SoftPC` is a file containing textual definitions of the configuration options for SoftPC. This file can either be edited with a normal UNIX editor or SoftPC will change values from menu selections. Once the standard files are in place, then you can go. Type

```
SoftPC
```

and you should see something very much like Figure 1.

Problems

I haven't encountered too many problems. But then perhaps I haven't stressed SoftPC too greatly. It has run all the programs that I have tried to use with no difficulty, and at an acceptable speed. The Norton Utilities' SI program ran correctly, giving SoftPC a score of 8.0 for its Computing Index and 10.7 for hard disk speed - this with no other significant UNIX tasks running on my Sun SPARCstation 1t. However, mouse handling is a little sluggish.

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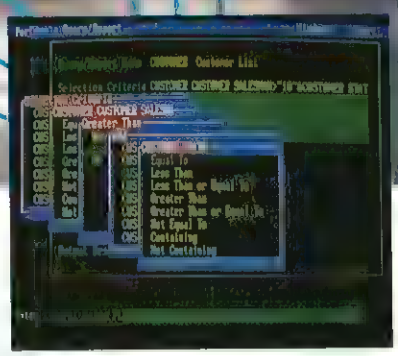

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You do need to recompile the SunOS kernel to include the System V IPC facilities, adding the lines

```
        # SV IPC message
options    IPCMESSAGE
        # SV IPC semaphore
options    IPCSEMAPHORE
        # SV IPC shared memory
options    IPCSHMEM
```

into the configuration file for your machine. Insignia's documentation doesn't tell you this.

The main problem is that SoftPC doesn't seem to tailor into the UNIX X environment very nicely. It works fine, but some things are a little painful.

For example, it tends to grab the mouse and not let go until you use the main selection menu to separate SoftPC mouse function and normal X operations. I feel that when you move outside the screen display area then the mouse should revert to its action in the window it is currently pointing to.

Also, the program also turns off keyboard auto-repeat. This is intrinsically no problem. However, the keyboard is a global resource. I do feel that a program turning keyboard repeat off should at least turn it back on when the program exits, which SoftPC doesn't. My current SoftPC command resets auto-repeat on exit from SoftPC by using the script:

```
#!/bin/sh
/h/SoftPC/SoftPC
xset r
```

You can also add a RAM disk, which is a big speed win

SoftPC tends to drop files in places that are not controllable by the user. For instance, the `cmos.ram` file must be on the user's home directory. Also, the file that shadows LIM memory is simply placed in the directory where SoftPC was started. This can be really inconvenient - I want to be able to say where it should be put.

SoftPC is big, around a 6 MB process image. My machine has a lot of memory and swaps from a local fast disk. The program starts reasonably speedily, I can imagine that it will be a mite slower if you are loading over NFS.

Overall assessment

All the problems above are small ones. I think that the product is reasonable. No-one is suggesting that you replace your PC hardware by SoftPC, if you have a lot of PC work, then simply buy a real machine. But for occasional use it works well and is usable. I think that running Aldus Pagemaker inside MicroSoft Windows 2 is a fair test of the emulator's capability. This runs just fine. All in all - a nice product.

EXE

Peter Collinson is a freelance consultant specialising in UNIX. He can be reached as `pc@hillside.co.uk` *electronically (although your mailer might be happier to put the address the other way round) or by phone on 0227 761824.*

SoftPC for SPARC is distributed by Technology PLC (0925 830404) and costs £595. You can get information describing the other versions (including Apple Macintosh and NeXT) direct from the manufacturer Insignia Solutions (0494 459426).

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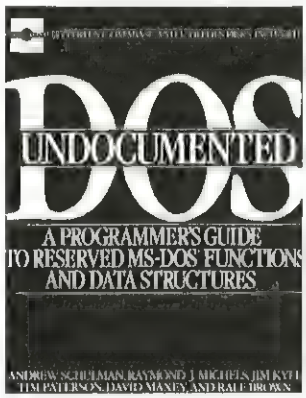

Many DOS programmers will have found that some tasks simply cannot be programmed using only the information contained in technical references. DOS has a secret side and programmers who know it can perform seemingly impossible tricks. It is intrinsic to the nature of secrets, however, that access to them is not easy, so to quite a few programmers, even serious DOS experts, a 700-page book titled *Undocumented DOS* will seem like manna from heaven.

Programmers who need to know about unlisted functions, mysterious structures and flags or just more detail on how DOS accomplishes its normal work have had to rely on the scattered, vague and often contradictory material published thus far - an unhappy situation indeed, which this book sets out to remedy.

For the most part, *Undocumented DOS* confines its scope to the central components of DOS. To DOS programmers, DOS is the Int 21h interface when seen from inside their programs and the command processor outside. System resources are examined from DOS's perspective to see how the information gained may be put to good use in applications.

However, the book is a lot more than a list of undocumented DOS functions and examples of their use. The reader (assumed to be fairly knowledgeable and treated as such throughout the book) is guided through programming techniques not often touched upon. Assembly language is used sparingly, the opportunity being taken to show how almost every topic (even TSR programming) can be implemented in a high-level language.

Still, whatever its objectives and style, a book on this subject, claiming to give detailed descriptions of DOS's undocumented functions and structures, is open to assessment on its comprehensiveness and the reliability of the information it contains.

The book's annotated list of undocumented DOS functions is an extract from the very much larger 'Interrupt List', well-known to the on-line community and described in the book as 'the one truly definitive, absolutely reliable list of DOS calls'. The full list is supplied in a hyper-text version on one of the 1.2 MB disks which accompany the book.

An objective assessment of the list's completeness is a little tricky, since the subject is to some extent open-ended. In those cases in which DOS calls other programs, it may simply be impossible to deduce everything about such calls from the code in DOS alone. Quite reasonably, the greatest effort has been concentrated on DOS's core and readers must expect to see the word 'unknown' when the book touches on matters outside its primary scope.

Against this, it must be remarked that there are several complete omissions even from the Int 21h interface and that the easy majority of unknowns can be resolved by inspection of only the DOS kernel and programs supplied with it as standard (particularly SHARE and IFSFUNC). Although only some contributing authors raise the matter of disassembly, it has certainly taken place. How else can it be known for instance that the unknown argument to Int 2Fh function 122Fh is required in register DX? Why else are those fields in the Swappable Data Area which are incremented or decremented in the DOS code described as 'unknown flag or counter' rather than just 'unknown'?

That the book should mention the Swappable Data Area at all, much less attempt to detail it and illustrate its effective use in TSRs, is very welcome and demonstrates that *Undocumented DOS* is more comprehensive than anything which has gone before. Also welcome is a discussion of the SEGDEBUG interface and documentation on network redirectors, a topic said to be mysterious even within Microsoft. Even so, the information given on redirectors is best viewed as exploratory, for it is too vague to be much help in writing a serious installable file system - it misses the attribute word at offset 0Ch in the IFS driver header, for instance.

Of course, omissions and incompleteness are not likely to cause harm. The authors are commendably frank about the limits to their knowledge and imbue a proper sense of caution. DOS features which are largely unknown are not going to be incorporated into tomorrow's software without further investigation by developers and the book does a good job of pointing the way, even providing a script-driven utility for spying on interrupt communications.

Much more concern must be given to the reliability of some descriptions of DOS's inner workings. Descriptions of memory allocation strategy and of actions taken to open a file contain errors of fact (although they may be popular misconceptions). According to the book, when DOS opens a file, it searches for a free entry in the handle table belonging to the current process and then for a free System File Table.In fact, it looks through the SFTs first - a difference which is not trivial, being the scurce of a DOS bug not mentioned in the book. Similarly, the distinction between a device driver and file need not be delayed as late as the book asserts; DOS's pathname parsing routine will search the device driver chain in some circumstances (the source of a bug which is mentioned in the book) and this is even shown in another chapter by the conversion of A:CON to A:/CON.

Perhaps it is unfair to labour such points, given a generally fine book, but precisely because *Undocumented DOS* will be regarded as a standard reference for its subject matter, it is important to note that it has lapses in reliability. This is nowhere more apparent than the several bugs which afflict the DEVLOD program for loading device drivers from the command line. In short, because its author does not seem to understand the reason behind one of the fields in DOS's List Of Lists, using DEVLOD to load ANSI.SYS from the command line has the possibly undesirable result that Ctrl-C and Ctrl-Break will not be effective when programs have their standard input redirected from a file. For much the same reason, combined with a misuse of undocumented function 32h, the ability of DEVLOD to load block device drivers in the presence of SUBSTed drives is suspect, despite claims. Thus, on a system with hard disk partitions C: and D: and a drive E substituted for a directory on drive C, using DEVLOD to load a block device driver (as drive F) is very unpleasant for drive D and is not a success for F: either.

More subtle is the construction of double-checks based on observations that are not supported by careful analysis. The clearest example is the run-time determination of System File Table size to allow verification against the size known from the DOS version number. The book assumes that the SFTs will be ordered AUX then CON, but this need not be true, for the arrangement can be manipulated by software using only documented DOS functions (though a good reason may be hard to produce).

Such problems aside, however, *Undocumented DOS* is a serious, responsible study which succeeds on the whole in demonstrating the safe use of DOS's secret side to expand programming horizons.

Title: Undocumented DOS *Author: Andrew Schulman, et al*
Publisher: Addison Wesley *Price: £39.95*
ISBN: 0-201-57064-5 *Pages: 700*

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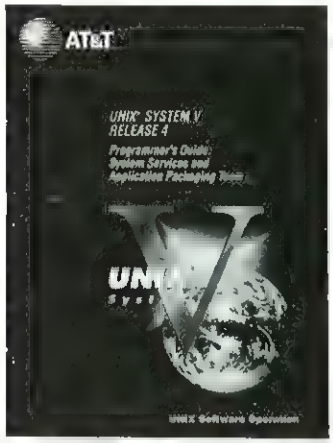

The first implementations of AT&T's UNIX System V Release 4 - the latest and the most powerful version of the UNIX operating system - are just starting to appear. Combining elements from a number of UNIX variants, such as Microsoft's XENIX, Sun Microsystem's Sun OS, and the BSD system, SVR4 has looks to be industry standard UNIX platform for the 1990s.

Prentice-Hall, in conjunction with AT&T, has produced a series of books to accompany the release. The full series comprises a staggering fifty titles, and covers most aspects of UNIX, including system administration, programming, and networking. As well as providing a separate series of titles for the Intel 80386 specific versions of the operating system, there is a graphics series covering both X Windows and Open Look, and a binary interface and compatibility specification set for a range of processors, including the Intel 80386, Motorola 68000 and Sun SPARC.

The books in the series are designed to compliment the documentation supplied by AT&T, and so all the information in the Prentice-Hall books can actually be found in the official AT&T documentation. These books will, however, appeal to large corporate users and training companies, as well as technical departments, who usually need multiple copies of technical material such as this. The books are by no means inexpensive - the four in this review alone cost over £100, but, for your money, you do get a weighty set of documentation, and bulk purchases of over 30 copies are eligible for discount.

The four books reviewed here are part of the general programming set, and can be viewed as a foundation series for programming under UNIX. They are not, though, the only technical books in the series, and programmers may find themselves having to refer to additional books, depending on the nature of the work. Although these books are aimed at generic UNIX, the AT&T 3B2 and 6386 computer systems are used as examples throughout the text, and, therefore, developers working with the Intel 386 family would be best advised to go for the 386 specific titles where possible.

The *Programmer's Guide: ANSI C and Programming Support Tools* is an introduction to the UNIX C compiler and the supporting programming tools. It is not an introduction to the C language, for it assumes some degree of proficiency in C programming on the part of the reader, as well as a basic understanding of the UNIX environment. The book concentrates on the compiler and linker, and using a tutorial style approach, the reader is taken through the basic set of operations in a 'try it and see' format. The latter part of the book is devoted to the utilities that accompany the development environment, including the symbolic debugger, the profiler, and source code control system, as well many of the well known UNIX utilities, such as `yacc` and `lex`.

The tutorial style used throughout the book works well, and the writing style remains relaxed and informal. If anything, the text sometimes verges on the verbose, which unfortunately tends to obscure, rather than clarify, particular points. Despite this, it contains just about all the information needed to get to grips with the UNIX C compiler.

The *Programmer's Guide: System Services and Application Packaging Tools* builds very much on the previous title in its coverage of programming under UNIX, and accordingly assumes a fair degree of fluency in the C language - and, again, some basic knowledge of UNIX principles. The emphasis of this book is on actually writing programs to operate under UNIX SVR4, and most of the book is devoted to an in depth examination of the system services and facilities available. The topics covered include file handling, memory management, process control, and inter- process communication.

The material here is more technically oriented, and this is reflected in the heavier reliance on source code extracts. There is also, unfortunately, a degree of terseness in the text, which makes reading heavy going at times. One other criticism that can be levelled at this book is the lack of full programming examples, a somewhat surprising state of affairs for a book so clearly aimed at programmers.

The essential volume for UNIX programmers is the *Programmer's Reference Manual*, which contains most of the information programmers will probably ever need to know about UNIX commands, C library routines and systems calls, not to mention file formats, and other miscellaneous details. Old time UNIX hackers will quickly recognise the MAN format used - the information is divided into short individual entries, one for each command, system call, structure and subroutine, and these are listed alphabetically, grouped into individual sections. Each of the entries is typically one or two pages long. Each one contains a brief synopsis, a fuller textual description, along with examples, notes, references or diagnostic information that may be relevant.

Once familiar with this style of presentation, it is surprising how well it works. The brevity and rigidity of the form restricts longer explanations - particularly in the coverage of the C library, where code examples are rare, and at most three or four lines. The only other problem is trying to hunt down information about a particular topic or subject matter, rather than a specific command or library routine. Fortunately there is a permuted index, in which all the significant terms are listed with a line long context, and page reference. This allows fast access to material, particularly when searching through multiple index entries.

Finally, the *POSIX Conformance* volume is a much slimmer affair of 50 pages, aimed at C programmers who need to write application programs that conform to the IEEE Portable Operating System Interface (POSIX) standards. In line with the requirements of the POSIX standard, this document outlines the implementation-defined features, as used by UNIX SVR4. It comprises two main sections. The first simply lists the values, limits and function prototypes for the header files `unistd.h` and `limits.h`, whilst the second section covers the implementation dependent features of the POSIX standard under UNIX SVR4. The resulting text consists of simple annotations to the P10003.1 standard, arranged in order of their appearance in that work. You'll probably need the standard by your side, since what is left consists almost entirely of tables and implementation statements. It's a specialised book, for programmers who need to work with the POSIX framework.

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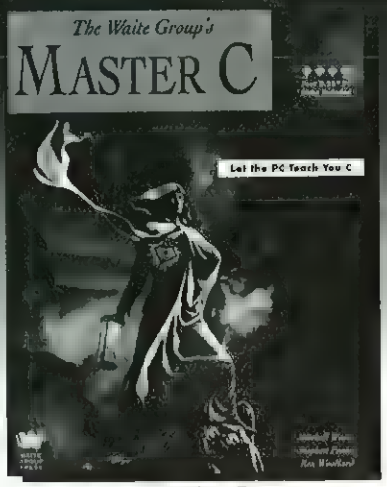

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For details of these and other positions contact Nick Hodson on the number below or out of office hours on 081-390 9518

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COMPANY	PRODUCT	CIRCLE NO
Bits Per Second	dGE 4.1	715
Blackwell Scientific Publictns	WinBasic	716
Borland	Borland C++	717
BSO Tasking	Real Time Executive/386	718
Computer Solutions	Catalogue	719
Defiant	Virus Hunter	720
Digital Research	Multiuser DOS	721
DRA	WordStar	722
Glockenspiel	CommonView	723
Hitex	C51 User Group	724
HP/Sun	OMF	725
Interactive	Unix V.4	726
Microsoft	Pen Windows/PDS	727
Mirabilis	LISTPACK+	728
MultiScope	Windows Debugger	729
OMG	Object Management Guide	730
Peripheral Land	SuperFloppy 1.4	731
QBS	Scripton	732
Solution Systems	Charge	733
System C	Sycero C for Unix	734
SystemStar	dbVista V3.2	735
Watcom	Watcom C/p16	736
WDA	Windows Development	737
WordPerfect	DOS Developer's Toolkit	738
Ziff Communications	Computer Select	739

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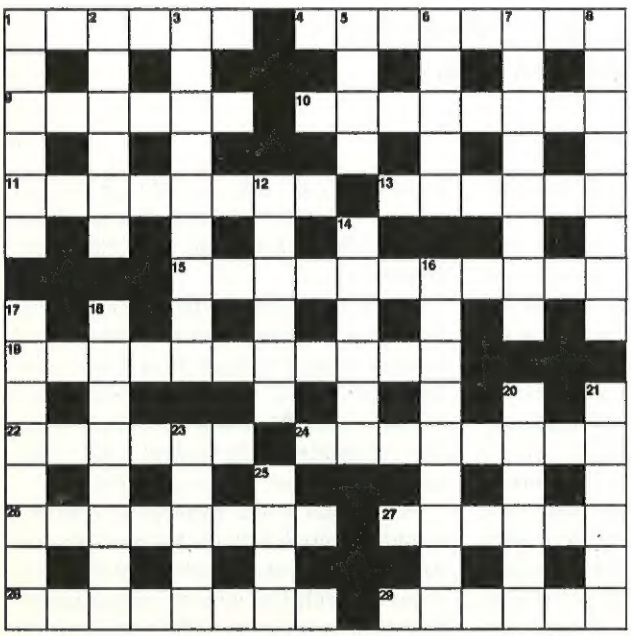
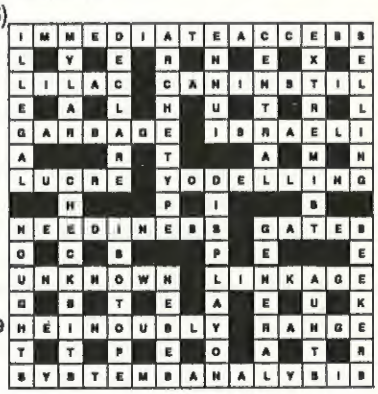


ACROSS

1 Keys to the simplest conditional (2,4)
4 Get together the source statements? (8)
9 Obtain second opinion on input (6)
10 Check out terminal in the bottom of the castle (8)
11 Repeats something about 21 (8)
13 Like Lady Diana on Saturday somewhere (6)
15 Practical appliance of knowledge, re software to us (11)
19 Remarks on printout (11)
22 Story of New Testament shows real skill (6)
24 Declare, and find yeti somehow (8)
26 Record presence in very immediate cell (8)
27 Symbol for aluminium in the message (6)
28 Lard fuel? No way - that's awful (8)
29 Bits of bits in a parallel process (6)

DOWN

1 Get NOTed! (6)
2 FOR x = 1 to 3 should do it (6)
3 Such a program does things right (9)
5 Network at the top of the bill...(4)
6 ...outside as well (5)
7 Comms board with a shot inside (8)
8 Twilight working time - not for odd people (8)
12 Crews from software houses? (6)
14 Save? (6)
16 Totally necessary as petrol in France may be (9)
17 Got data by force? (8)
18 Good model of wavy 27 (8)
20 Link between IT and molecular engineering? (6)
21 Units of machine action on the road (6)
23 Sensed information as child rose over the man (5)
25 Mouth-watering choice? (4)



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ADVERTISERS INDEX

ADVERTISER	PRODUCT/SERVICE	CIRCLE	PAGE
Addison Wesley	Book Publishers	707	89
Bits Per Second	Graphics Server Software	674	50
Bits Per Second	Graphics for dBASE	693	76
BL Security	Software Protection	685	61
Blenheim Online	Software Tools Exhibition	694	77
Blinker	Clipper Fast Linker	656	21
Borland	DOS and Windows Programming	663	33
Borland Competition	Competition	648	6
Brent Communications	MAX copy PROtection	677	51
Camel	Plotter Utilities	676	51
CEBRA Communications	Multi VGA Adapters	679	52
Computer Bookshops	Computer Books Distribution	708	91
Comsec	Software Copy Protection	697	81
CTL	Copy Protection Hardware	684	61
DES	Software Protection	681	54
EIUG	Informix User Group	696	64
Eurosnow	UNIX Report Generator	702	85
Expert Systems	Prolog for Windows	652	17
Glockenspiel	C++ Windows 3 Library	655	19
Grey Matter	Programming Tools	646	3
Highland Graphix	Graphics Menu	660	29
Intasoft	Software Management System	653	17
IXI	UNIX Software and Training	712	64
Jensen & Partners	C++ Compiler	670	41
KJD	IBM PC Upgrade	701	84
Lahey	FORTRAN Compilers	704	86
Linx I	All UNIX Systems	691	70
Linx II	All UNIX Systems	709	91
LPA	AI/KBS/OOPS Software	666	39
Magnifeye	Software Protection Device	672	47
Microcosm	Copy Protection Software	703	86
Microft Technology	Network Security	680	53
Microsoft I	C Compiler	661	27/29
Microsoft II	Windows 3.0	683	56/57
New Dimension Technologies	Multi-Platform xBase	664	34
Nu-Mega	Debugging Tools	651	14
Pecan	The Pecan Power System	658	25
Pinna Electronics I	Tools & Graphics	705	86
Programmer's Odyssey	UNIX Software	711	40
Prospero	DOS Extender Kit	670	44
QA I	Network Training	645	IFC
QAII	4GL Development Tools	687	63
QBS	Clipper Add-ons	698	81
Rainbow Technologies	Software Data Security	647	5
Real Time Software	CASE for Windows	654	17
Recital	RDBMS/4GL for VAX & UNIX	692	75
Roundhill	Development Tools	669	42
Salford	FORTRAN for DOS and UNIX	668	39
SCL	Communications Boards	688	64
Select Software	CASE Tools	667	39
Sequiter	C Library	682	55
Softlok International	Piracy Protection	695	78
S/ware Construction Company	Development Tools	671	45
S/ware Generation	Code Generator	657	22
S/ware Paradise	Business Software Sales	690	68/69
Solution Systems	Programming Editor	665	37
System C	Program Generators	700	83
System Science I	Development Tools	686	61
System Science II	Windows Tools	699	81
System Science III	Version Control System	675	50
System Star	dbms Four C	649	9
Univision	UNIX Development Systems	706	87
USA Software	Programming Tools	662	30
User Friendly	Software Copy Protection	678	52
Vleermuis	C++ Class Tree OS/2	650	11
Watcom	C Compiler	710	OBC
Zortech I	Multi Plat C++ Comps	673	49
Zortech II	C++ Video Tutorial	689	67

STOB - Upgrade

The latest upgrade from Will 'n' Dave's Software Ltd, WADSbase V3.2, has arrived at Stob's offices.

I'm sitting with the girls in the 'canteen' (sink, kettle, one spoon, plus an old, broken toaster that the MD brought in because he thought one of us might like to 'try and get it going'), mulling over who is the most fanciable TV cop. Trace has already poured scorn on Julie's suggestion of Morse ('but he's so *old*, and he's a slob'), and Julie's reciprocated by crushing Trace's nominee of Nighthawk ('a slime-bag, and he's never home nights'). Both now warming up to have a go at *my* sweetheart, Spender (old, slob, slime-bag, thinks he's a rock star), when Mike comes in with a parcel for me.

Adjourn debate, and return to my office clutching prize. Package proves to contain the new wonder-release of WADSbase, with added compiler RAM-packing CUA SQL OOP active liposome extensions that will revolutionise your code and help prevent the signs of ageing. There are three ring-bound manuals, an envelope containing six x 1.2 MB flops, a set of dividers and a good handful of polystyrene petals just ripe for stuffing down Julie's neck. Rip open envelope (thus implicitly agreeing, in the event of unauthorised duplication, to consign my unborn children to slavery) and take permitted single backup of disks like you are supposed to, for oh! what a good girl am I. Assemble manual components. This is the bit the magazine reviewers always whinge about, rendered complacent by much too much free software. Ah, the excitement of slitting open the Cellophane, the smell of the unthumbed pages, the wonderful sentences that come from automatic spell-checking of technical English ('...do not attempt to decompose your interpretives...'), the discovery of three Section 2s...

Place extra Section 2s in death-to-pirates envelope, disk 1 in cake-hole B:, run INSTALL.EXE. Much drive churning, followed by multicoloured screen containing more questions than a poll-tax evasion form. Do I want to overwrite previous version of WADSbase? Yeah, what the hell. This completed, hit ENTER, feed in disks as requested, fine. Edit CONFIG.SYS and remove the 'FILES=20' line that has been inserted beneath the old line 'FILES=20'. Ready to go.

Switch to the Johnson directory, compile the report program as shown in Section 2 number 1, run it, lock up. Boot, back to the directory, edit the source. Complete source file now reads ◆£a*beep*!#ë, which is not how I remember it. Excitement at new compiler rapidly turns to dust, then fury.

Think: what would Spender do? Spender would call up WADS on his portable and abuse them in witty Geordie. WADS having come up with the wheeze of putting its Technical Support on 0898 (peaktime 48 pee per grunt) number, and such numbers having been rendered mechanically undialable from office phones by our toaster-manager, this option not open.

Julie puts her head round the door to say What about Bergerac's bottom; 'cos Trace says he's put on weight recently. Test polystyrene petals. Petals work fine.

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